IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF MASSACHUSETTS

MASSACHUSETTS INSTITUTE OF TECHNOLOGY, Plaintiff, v. HARMAN INTERNATIONAL INDUSTRIES, INCORPORATED, Defendant.	Civil Action No.: 05-10990 DPW Magistrate Judge Judith G. Dein

MIT'S COUNTER-STATEMENT OF FACTS PURSUANT TO LOCAL RULE 56.1 IN SUPPORT OF MIT'S OPPOSITION TO HARMAN'S MOTION FOR SUMMARY JUDGMENT THAT CLAIMS 1, 42, AND 45 OF THE '685 PATENT ARE INVALID UNDER 35 U.S.C. § 102(b)
AND
IN SUPPORT OF MIT'S CROSS-MOTION FOR PARTIAL SUMMARY JUDGMENT THAT CLAIMS 1, 42, AND 45 OF THE '685 PATENT ARE NOT INVALID UNDER 35 U.S.C. § 102(b)

MIT'S STATEMENT OF UNDISPUTED FACTS

The '685 Patent History

1. U.S. Patent No. 5,177,685 ("the '685 patent"), which is assigned to MIT, was filed on August 9, 1990, and therefore, the "critical date" for purposes of 35 U.S.C. § 102(b) is August 9, 1989. Exh. 1 at cover page.

2. The '685 patent was based on a doctoral research project called "Back Seat Driver" conducted at MIT by James R. Davis, under the guidance of MIT research scientist Christopher Schmandt. The inventors disclosed all of their publications regarding the Back Seat Driver research to the Patent Office, including the thesis, which was not prior art because it was not a "printed publication" before the critical date. Exh. 1 at cover page, 1:59-62; Exh. 2 at 5; Exh. 3 at 376.

3. The inventions of the '685 patent involve an automobile, and experimentation of the inventions necessarily required field trials occurring on public streets that formed part of the digitized map. Exh. 2 at 2, 149-153.

4. NEC Home Electronics ("NEC") sponsored the "Back Seat Driver" research. Exh. 4 at 1958; Exh. 2 at 4.

Multiple Versions Of The Back Seat Driver Research Prototype

5. The "Back Seat Driver" research included multiple versions of research prototypes. Exh. 5 at 4-8; Exh. 6 at 1377; Exh. 7 at 112-113; Exh. 8 at 177:9-17.

6. Although all of the research prototypes were referred to as "Back Seat Driver," including in papers published by Davis and/or Schmandt and correspondence between the inventors and NEC, not all of the research prototypes embodied the claims of the '685 patent. Exh. 7 at 111-113; Exh. 5 at 4-8.

7. "Version 0" of the "Back Seat Driver" was a computer simulation. Exh. 6 at 1377. "Version 1" of the "Back Seat Driver" and "Version 2" of the "Back Seat Driver" both featured a "person in the back…[to] provide position information by entering data silently on a laptop computer." *Id.*

8. The inventors noted that "[a]ll these versions, especially 1 and 2, will evolve through testing and change as they are evaluated." Exh. 6 at 1377.

9. "Version 3" of the "Back Seat Driver" was to "include onboard position sensing hardware, removing the requirement for a human substitute." Exh. 6 at 1377.

10. In a report dated April 30, 1989, the inventors reported that the concept of the Back Seat Driver seemed to be working well as tested in "Version 2." Exh. 7 at 111.

11. Version 2 of the Back Seat Driver discussed in the April 30, 1989 letter did not embody the claimed inventions. In Version 2, "the NEC speed sensor provide[d] a count of odometer rotation to a laptop computer. A human operator provide[d] direction information by entering directions of turns as single keystrokes on the laptop. The laptop then transmit[ted] distance and direction traveled via cellular modem to [a] workstation computer." Exh. 7 at 111.

12. Version 2 of the Back Seat Driver involved communications problems between the equipment in the car and the equipment in the Media Lab. Exh. 7 at 111. The communications problems were two-fold: 1) "noise in the [data] channel" and 2) "the modem…dropping the connection after only a few minutes." *Id.*

13. The inventors attempted to solve the first problem by using a "cellular modem manufactured by Spectrum Cellular Corporation…[which] eliminated almost all noise in the data channel, but [was] only somewhat better at tolerating loss of carrier than the landline modem." Exh. 7 at 111.

14. The inventors advised NEC that Version 2 was not commercially exploitable because of the human operator and the lack of reliability of the system due to the loss of cellular signal. Exh. 7 at 111-113:

> [W]e still have difficulties when the human gets confused and provides false information to the workstation…we think the next step is to move the implementation from the workstation computer to a computer installed in the trunk of the car. Doing so would remove our dependence on cellular phones, making the system more reliable, cheaper, and a much more convincing 'concept car'.

15. The "loss of carrier problem" continued until at least the completion of Dr. Davis' Ph.D. thesis. In a report dated July 31, 1989, the inventors advised NEC that,

> [i]n the previous quarter, we began using the Spectrum Cellular modem, which provides a clean data transmission channel. At that time, we still had problems with loss of carrier. This remains a problem. We still find that calls are sometimes dropped. We have found this to be about as bad with voice calls as with data calls, so we attribute it to the cellular system as a whole, not to the modem or cellular phone. We do not expect any solution to this problem.

Exh. 9 at 175.

16. "Version 3" was not implemented until after the critical date. Exh. 10 at 14:12-21; Exh. 11 at 80:14-21.

17. During spring of 1989, Davis and Schmandt hired an undergraduate student, Gregory Grove, to work on the specific problem of loss of carrier signal between the car and the workstation. Exh. 12 at 709860:

> I will be in the car monitoring the carrier status and operating the positioning system. When the carrier is lost, I will log time, location, and conditions surrounding the loss of carrier. I will investigate why the carrier was lost…Firm establishment of cellular phone/modem communication would benefit the project by making it a much more viable system.

18. Mr. Grove failed to solve the data communication problem by the time he submitted his

"UROP Final Paper" to Schmandt on May 20, 1989. Exh. 13 at 709862, 709877 ("I could do little more than calculate the probabilities for loss of carrier").

19. Neither Harman nor Mr. Grove produced any documents showing that Mr. Grove was allowed to drive the Back Seat Driver automobile during any field trial of any version of the Back Seat Driver, even though he worked on the project.

20. Neither Harman nor Mr. Grove has produced an affidavit or other evidence to authenticate any of the documents produced by Harman from Mr. Grove's files.

21. Harman has represented that it will not be calling Mr. Grove at trial.

22. Davis continued testing the strength and durability of the voice and data communication channels during the Summer of 1989 and into 1990, and he maintained records of the performance of the communication channels during this durability testing. Exh. 14 at 4390-95; Exh. 2 at 149-153.

23. In Version 2 of the Back Seat Driver prototype, the inventors noticed a problem with delay in data packets arriving from the automobile at the workstation computer. The data packets would subsequently arrive after the automobile had moved, decreasing the reliability of Version 2. Exh 9 at 175 ("if there is difficulty transmitting a packet, all successive packets are also delayed until the first one is transmitted. For ordinary data, this is a desirable feature, but for real time data such as positions this is not desirable.").

24. The loss of carrier and delay problems were not completely solved until after the critical date when the computer was on-board the vehicle. Exh. 8 at 161:15-23; Exh. 10 at 14:12-21:

Q: Do you recall what you did in terms of development of "The Back Seat Driver" from September of 1989 to September of 1990?
A: Yes.
Q: What did you do?
A: Among other things, we built another prototype of the system where the computer was installed in the car instead of using the cellular telephone apparatus to communicate to a

computer that remains stationary.

Exh. 11 at 80:14-21:

A. Okay. So when you asked me about [claims] 57 and 58 [relating to cellular telephone embodiment], I believe that I said that all versions of the Back Seat Driver had those elements in them. What the correct thing to say is, all versions of those as of up to and including August of 1989, had those features. Subsequent versions did not necessarily have those features.
Q: Thank you.

25. The inventors did not receive the "NEC Vehicle Navigation System for positioning information" that was required for Version 3 of the Back Seat Driver prototype until "the final weeks of the project." Even after they received it, the inventors "found several difficulties with the design and operation of the [NEC Vehicle] Navigation System." Exh. 6 at 1377; Exh. 9 at 176.

26. Any field trials of the Back Seat Driver that occurred prior to the Final Report dated July 31, 1989, would not have been field trials of the claimed invention. Exh. 9 at 176.

Circumstances Surrounding The Field Trials

27. Some pieces of equipment used in the field trials of prototypes of the Back Seat Driver were installed in an 1988 Acura Legend automobile. Exh. 15 at 1966. These pieces of equipment included, at most, the "driver input means," the "position sensor," and the "voice apparatus." Exh. 16 at ¶¶ 118-120; Exh. 17 at 6763; Exh. 18 at 6765; Exh. 2 at 149-153; Exh. 19 at 710321:

> Two cellular telephones link a based computer to the car. The Back Seat Driver transmits the car's position and speed back to the [Media L]ab's computer via modem and telephone … Synthesized instructions are relayed to the driver through the second cellular telephone, which is a speakerphone. The keypad of that phone also serves as the driver's control unit for the system, allowing him to select a destination and request a repeat of previous instructions.

28. The rest of the equipment used for the field trials of prototypes was located at the MIT

Media Lab. Exh. 16 at ¶¶ 118, 120; Exh. 7 at 111; Exh. 19 at 710321; Exh. 2 at 149-153.

29. The automobile equipped with the Back Seat Driver components was stored in a private MIT parking garage that had card access. Exh. 8 at 160:22-161:10.

30. The field trials involved a driver driving the car and reacting to driving instructions generated at the Media Lab and sent over a cellular communications connection to a cellular telephone in the car. Exh. 17 at 6763; Exh. 18 at 6765.

31. Davis or Schmandt was always in the car during any field trial. Exh. 10 at 31:14-17 ("'The Back Seat Driver' was always a research prototype, and I attempted to learn things from every experience I had of 'The Back Seat Driver.'"); Exh. 17 at 6763; Exh. 18 at 6765; Exh. 11 at 12:5-18:

Q: Is it also likely to believe – or is it likely and reasonable to believe that somebody was driving the Back Seat Driver on a public road in the Boston area in the month of August of 1989?
A: I think it's highly unlikely.
Q: Why do you say that?
A: Because in the month of August, Jim, who would have been the principal researcher – I'm sorry, *the researcher would have been in the car in the course of those trials*, those drivings, was working very hard to finish his thesis. And it is certainly possible that driving would have occurred, but I think it's highly unlikely because I think at that point he had a very large document to produce."

Id. (emphasis added).

32. No driver could have driven the automobile without Davis or Schmandt present to record observations. Exh. 11 at 12:5-18.

33. MIT retained ownership of the Acura Legend and the equipment therein until after the critical date. Exh. 15 at 1966; Exh. 8 at 177:9-17.

34. The Acura Legend that housed prototype components was sold back to NEC with the navigation equipment inside it after the Back Seat Driver research concluded, on or around September 1992 and after the application for the '685 patent was filed. Exh. 8 at 177:9-17:

Q: Do you still have [the Back Seat Driver system]?
A: No.
Q: What happened to it?
A: NEC repurchased the vehicle from us and took the equipment with it.
Q: When did they do that?
A: At the end of the research period.
Q: Which was when?
A: It would have been – I can't tell you the exact date, because I'm not sure when it ended, because we took a no cost extension, probably sometime in 1992.

35. MIT made a promotional video of an operational version of the Back Seat Driver in 1990, after the critical date. Exh. 10 at 80:24-81:11:

Q: Do you know whether Mr. Schmandt ever demonstrated 'The Back Seat Driver' of [*sic*] system at any of these conferences, like the one in June of '89?
A: I do not think it would have been possible for him to demonstrate the system, since to do that he would have to bring the car with him, and that wouldn't be easy to do.
Q: Well, a videotape was made of 'The Back Seat Driver' system, correct?
A: I believe the video – there was a videotape made. I believe it was made subsequent to September of '89.

Exh. 8 at 178:22-179:8:

A: I don't remember who in particular has seen it. I have shown that video to many, many people.
Q: What video?
A: The Back Seat Driver video.
MR. LEAVELL: Do we have a copy of that? Has that been produced?
THE WITNESS: I hope so. It's publicly available on my website.
MR. LEAVELL: Okay.
Q: When was that video shot?
A: 1990.

36. Davis and Schmandt continued to test the reliability of cellular telephone communications throughout 1989 and recorded their test results. Exh. 14 at 4390-95.

37. Davis and Schmandt continued to change aspects of the Back Seat Driver prototype throughout the summer of 1989 in response to field trials that occurred. Exh. 11 at 12:19-13:12:

Q: Let's talk about the system as it existed in June and July of 1989.
First of all, is there any reason to believe that any changes to the Back Seat Driver took place between June and July of 1989 or can we talk about that as one system?
A: There is no record of any changes. However, it is highly likely that there were changes.

Q: What do you say that?
A: Because at that time Jim was working very hard on finishing learning what he needed to learn and making the modifications to the software that he needed to make in order to call his thesis complete. The purposes of these field trials was to debug and evaluate his software. Therefore, if he learned anything and during any one of these drives, he almost certainly would have fixed that in which case each subsequent drive would have had different possible behavior.

38. The problem of carrier loss was not solved until the computing apparatus was operated on-board the Acura Legend, which did not occur until after the critical date. Exh. 2 at 110; Exh. 4 at 1961-62; Exh. 10 at 14:12-21.

39. An industry press article from the Automotive Electronic News dated July 17, 1989, acknowledges that the prototype of the "Back Seat Driver" in use at that time was not a completed product and that changes to the system were ongoing. Exh. 19 at 710321 ("The next step in the Back Seat Driver's development, according to the researchers, is to determine exactly what a speech guidance system should say, how time and vehicle speed affect the instructions it gives, and what features a map database must have to support the generation of useful spoken instructions.").

40. Dr. Davis testified that no one observing the car either from the street or in the car itself would understand how the invention was working. Exh. 10 at 104:22-105:13:

Q: Let me be more specific. When you were driving around Boston and Cambridge in 'The Back Seat Driver,' did you take any steps to protect the secrecy or confidentiality of the system?
A: No one looking at the car from the outside would have any reason to suspect that there was anything unusual in the car. It's certainly not necessary to, you know, disguise the car.
You can't tell from looking what's going on. So it was not necessary to do the trials only at night or something if that's what you're getting at.
Q: I'm getting at anything. Is there anything that you did to ensure people weren't observing or listening or watching what you were doing?
A: It wasn't necessary.

41. Dr. Davis testified during his deposition that he was not certain the Back Seat Driver was perfected until after this thesis was finalized, and the on-board computer was used. Exh. 10 at 169:4-13:

Q: Did you continue to use the working 'Back Seat Driver' with other people around the Boston area between June of '89, which you say is when you knew it would work, and August of '89, when you signed your thesis paper?
A: First of all, I think what I testified is that by June of '89 I was confident that the system would work. The date that that confidence began to appear, I'm not sure what the earliest date of confidence was.

See also id. at 14:12-21.

42. The people that were allowed to field trial the Acura Legend were trusted friends, colleagues, and supporters of Davis, Schmandt, or the MIT Media Lab, all of whom recognized an implied duty to keep the research private, including Davis' now-wife, his research sponsor NEC, members of his thesis committee, student test subjects, and entities that understood Media Lab sponsorship. Exh. 10 at 178:8-10, 23-179:8; Exh. 17 at 6763; Exh. 18 at 6765; Exh. 21 at ¶¶ 8-9; Exh. 22 at 303:3-12.

43. The purpose of the field trials was to ensure that the system was "safe, effective, durable and repeatable." Exh. 21 at ¶ 8.

44. Aspects of the Back Seat Driver system, including its "discourse generator," changed in response to the field trials occurring in the summer of 1989. Exh. 11 at 20:5-13:

Q: How do you know that changes were made to the Discourse Generator after June of 1989?
MS. MOTTLEY: Same objection.
A: Because the changes that Jim Davis would have been working on to complete his thesis would have been aspects of the Discourse Generator.
Q: How do you know that?
MS. MOTTLEY: Same objection.
A: Because I was his thesis advisor.

Id. at 23:11-24:5:

Q: As of June of 1989, were you and Mr. Davis reasonably sure that you had developed a Discourse Generator that would work for its intended purpose as of that date?
MS. MOTTLEY: Same objection.
A: Clearly, we believed there was something – that we had built something that was beginning to work. We didn't believe it was a finished product or product not something for sale. Product means a piece of research. There were certainly changes that needed to be made.

There were certainly – during that time period there were certainly changes that needed to be made in order for Jim to – for us to consider the work to be completed enough for Jim to get his thesis. Nonetheless, in June, we certainly – we both would have predicted with relative confidence that Jim's thesis was going to be finished at the end of the summer.

Source Code of the Back Seat Driver System

45. The "Back Seat Driver" used a software system running on a computer. Exh. 2 at 16; Exh. 1 at 3:25.

46. The "Back Seat Driver" was controlled by source code written by Davis. Exh. 10 at 212:9-17.

47. The source code files produced by MIT in this litigation demonstrate that Davis was making changes to the Back Seat Driver right up until the day the application for the '685 patent was filed, and continued to improve non-claimed features even afterwards. Exh. 23 at 4493.

48. Neither Harman nor its experts have relied on the "Back Seat Driver" source code for any positions they have taken regarding validity or enforceability of the '685 patent.

49. The source code, which was running the Back Seat Driver system, was not shown or made available to test subjects. Exh. 21 at ¶ 9.

50. Mr. Grove, who as an undergraduate researcher and was "an integral part of the operation of the Backseat Driver," "was never able to see the code of the program running the Backseat Driver," even though he believed himself to be "reasonably proficient in LISP [the language running the system]." Exh. 13 at 709876-877.

Jim Davis' Ph.D. Thesis and Defense

51. The only electronic copies of Davis' Ph.D. thesis were stored on a password-protected computer at the MIT Media Lab in a room that had keypad access. Exh. 11 at 113:19-23, 114:3-115:4; Exh. 24 at ¶ 3.

52. Davis and Schmandt were the only people who knew the password. Exh. 11 at 115:14-

23; Exh. 24 at ¶ 4.

53. Davis' thesis was not publicly available until February 27, 1990, at the earliest; although Davis signed his thesis August 4, 1989. Exh. 2 at cover page; Exh. 11 at 112:23-113:12:

Q: Is there any evidence that anyone took any steps to preserve the confidentiality of Mr. Davis' thesis paper or drafts of his thesis paper at any time prior to August 9th, 1989?
A: Yes.
Q: What is the evidence?
A: The thesis was received at the M.I.T. library on February 27, 1990. The date is stamped on the thesis and has been verified with the library. That means the thesis was not turned over to the library for public dissemination until February 27, 1990. It was not shelved until September 1990, nor was it catalogued until that time. That's normal M.I.T. library delay.

54. Davis' thesis was not available to the public until it was shelved in the MIT Library, in September of 1990. Exh. 11 at 113:10-12.

55. A graduate student from the University of Minnesota requested an early copy of Davis' thesis, but he did not send the thesis to her. Exh. 21 at ¶ 5; Exh. 10 at 71:19-72:10:

Q: Is there any reason to doubt that you forwarded [Ms. Stuck, the graduate student] a copy of your thesis proposal in or around May of 1989?
A: There is no evidence here one way or the other.
Q: Does that sound like something you would have done back in May of 1989?
MR BAUER: Objection Speculation.
A: So one would speculate, I do speculate, that given such a request, I might have sent her the thesis proposal, which would describe what problem I was attempting to solve and why it was a novel solution, a novel problem, a problem worthy of attention. But it would not, of course, describe the actual solutions or conclusions of the work, only what's the problem.

56. No one else outside of Davis' trusted colleagues through MIT requested information about the Back Seat Driver prior to August of 1989. Exh. 10 at 70:9-15:

Q: Prior to August of 1989, did you ever receive any additional requests from anyone, aside from Ms. Stuck, for information about 'The Back Seat Driver' project?
A: You mean by that people outside of M.I.T.?
Q: Let's start there. Correct.
A. No.

57. Drafts of Davis' thesis were not public documents per MIT policy. Exh. 11 at 116:23-117:7:

Q: Is there any other evidence that M.I.T. contends supports any steps that were taken to preserve the confidentiality of Mr. Davis' thesis paper or drafts thereof during the time period prior to August 9th of 1989?
A: It's generally University policy, and M.I.T. is no exception, that drafts of documents such as thesis are not public. They are not to be distributed publicly.

58. The route-finder of Davis' "Direction Assistance" program did not allow for the driver to make an illegal U turn. Exh. 25 at 10.

59. Davis' thesis does not mention that the Back Seat Driver system could handle illegal U turns. Exh. 2 at 67 (citing the absence of this information).

60. Davis learned that his system would need to account for illegal U turns after a field trial with a General Motors driver. Exh. 10 at 31:10-32:9.

61. Drafts of Jim Davis' Ph.D. thesis were not publicly distributed. Exh. 11 at 116:23-117:7; *see also* Exh. 24 at ¶ 6; Exh. 21 at ¶ 7.

62. Jim Davis did not print copies of his thesis or drafts and give them to the general public. Exh. 21 at ¶ 2; Exh. 11 at 116:23-117:7; *see also* Exh. 24 at ¶ 3.

63. Jim Davis defended his thesis sometime in the fall of 1989 after continued development and field trials conducted in the Summer of 1989. Exh. 24 at ¶ 7; Exh. 21 at ¶ 6.

64. Prior to its publication in the MIT library, the only people who would have received drafts or a finalized version of Jim Davis' thesis would have been actual members of Jim Davis' thesis committee or colleagues acting in an academic advisory capacity. Exh. 21 at ¶ 7.

65. The "flyer" Harman relies on to "show" that Jim Davis defended his thesis on May 26, 1989, is a draft with typographical errors and handwritten corrections. Exh. 21 at ¶ 6; *see also* Docket No. 146 at 5.

66. Jim Davis did not defend his thesis on May 26, 1989. Exh. 24 at ¶ 7; Exh. 21 at ¶ 6.

67. Jim Davis was not ready to defend his thesis in May of 1989. Exh. 21 at ¶ 6.

68. The May 26, 1989, draft was created at a time when Jim Davis thought he might be able to graduate in June of 1989. Exh. 21 at ¶ 6.

69. Phil Rittmueller did not receive a copy of the "Back Seat Driver Final Report," which bore a date of July 31, 1989, and attachments thereto, until after Jim Davis' thesis was completed. Exh. 22 at 149:4-16, 150:24-154:21; Exh. 21 at ¶ 3.

70. Phil Rittmueller did not receive a copy of Jim Davis' thesis before Jim Davis finished the thesis. Exh. 22 at 64:13-65:19.

71. Phil Rittmueller did not receive a copy of Jim Davis' thesis until after the thesis was available in MIT's library. Exh. 22 at 153:24-154:21; Exh. 24 at ¶ 5.

72. Phil Rittmueller understood that communications with Jim Davis and Chris Schmandt were confidential or "close to the vest." Exh. 22 at 303:3-12, 305:23-306:5; Exh. 24 at ¶ 6.

73. The public did not have access to copies of Jim Davis' thesis until the thesis was shelved in MIT's library. Exh. 24 at ¶ 8; Exh. 11 at 113: 5-12.

74. Any copies of Jim Davis' thesis that were sent to Lynn Streeter were done so with a view towards obtaining feedback from a professional colleague in an advisory role. Exh. 21 at ¶ 4.

75. Lynn Streeter recognized academic and ethical obligations kept Jim Davis' thesis from being publicly available. Exh. 26 at ¶¶ 3, 7.

76. Formal "restrictions" regarding confidentiality were not necessary because Lynn Streeter was a colleague of Jim Davis and Chris Schmandt. Exh. 21 at ¶ 4.

77. Drafts of Jim Davis' thesis were not available or distributed publicly. Exh. 11 at 113:13-21, 116:23-117:7; Exh. 24 at ¶ 3.

MIT'S RESPONSE TO HARMAN'S STATEMENT OF UNDISPUTED FACTS

1. **Harman's SOF 1**: "The patent application that matured into the '685 patent was filed on August 9, 1990."

MIT's Response

MIT does not dispute this.

2. **Harman's SOF 2**: "In the late 1980's, Jim Davis was a graduate student at MIT working in the MIT Media Lab under his faculty advisor, Chris Schmandt, who also served as the Director of the Speech Research Group."[1]

MIT's Response

MIT does not dispute this.

3. **Harman's SOF 3**: "At least as early as April, 1988, Davis and Schmandt conceived of the project called the Back Seat Driver that involved automobile navigation using spoken directions, including the subject matter of claims 1 and 42 of the '685 patent."

MIT's Response

MIT does not dispute that there was a research project called Back Seat Driver. This statement of fact is vague, however, insofar as Harman fails to specify which version(s) of the Back Seat Driver this statement of fact refers to. MIT disputes any inference Harman seeks to draw that the Back Seat Driver was publicly accessible or in the public domain in April 1988.

4. **Harman's SOF 4**: "By the end of April 1989, the Back Seat Driver was 'working well' and had made 'dozens' of 'successful' uses, including uses by subjects."

MIT's Response

MIT disputes this statement of fact and the inferences Harman seeks to draw from this

[1] MIT does not address herein the headings found throughout Harman's Statement of Facts.

statement. As pointed out above, Harman fails to identify which version of the "Back Seat Driver" prototypes this statement of fact refers to. Based on the letter and the published paper Harman refers to, the version of the system Harman refers to appears to be "Version 2" of the system, which did not embody the content of any of claims 1, 42, or 45 at least because "Version 2" required a human operator to ride in the vehicle. *See* Exh. 7 at 111. Moreover, Harman mischaracterizes and misquotes the reference that Harman relies upon. The Report dated April 30, 1989, refers to "successful trips," not successful "uses," which is a legal conclusion. This point was clarified during MIT's Rule 30(b)(6) testimony:

Q: What about Claim 3 in the '685 patent, did the Back Seat Driver, as it existed in the successful field trials in June of '89, include the subject matter recited in Claim 3 of the '685 patent?
MS. MOTTLEY: Same objections.
A: I'm concerned because suddenly you've introduced the word successful. You refer to successful field trials.
Q: Let me rephrase –
A: There was not any particular metric of success in these.

Exh. 11 at 26:2-12.

5. **<u>Harman's SOF 5</u>**: "The Back Seat Driver was a working system, on the road, on the public streets around Boston, at least as early as June 9, 1989."

<u>MIT's Response</u>

MIT disputes this statement of fact and the inferences Harman seeks to draw from this statement. MIT does not dispute that an abstract for a paper authored by Schmandt and Davis was dated June 9, 1989. MIT disputes Harman's characterization of the Back Seat Driver as a "working system," which implies commercial readiness. Both references that Harman cites to state, "The Back Seat Driver is a research prototype of a system…We are evaluating the user interface by field trials." *See* Docket No. 144 at 12.

6. **<u>Harman's SOF 6</u>**: "From May 1, 1989 through July 31, 1989, approximately 50 persons drove around Boston using MIT's Back Seat Driver system."

<u>MIT's Response</u>

MIT disputes the inferences Harman seeks to draw from this statement suggesting there was final system. MIT disputes Harman's conclusion that any of the people driving a vehicle equipped with Back Seat Driver equipment "used' or were "using" the "Back Seat Driver system" as the term "use" has a legal meaning in this context. As pointed out above, Harman fails to identify which version of the "Back Seat Driver" prototype this statement of fact refers to. MIT also objects to Harman's mischaracterization of the documents Harman cites -- they refer to "50 subjects," clearly implying experimentation and testing. Exh. 21 at ¶¶ 8-9.

7. **<u>Harman's SOF 7</u>**: "People who used or saw a working Back Seat Driver system on the public streets of Boston include MIT students, members of Davis' thesis committee, Mr. Rittmueller, other NEC employees, General Motors personnel, and other third parties."

<u>MIT's Response</u>

MIT disputes this statement of fact and the inferences Harman seeks to draw from this statement. First, there is no evidence anyone "saw" the system on the public streets, other than those working with the inventors. Second, none of the people identified by Harman *saw* the "Back Seat Driver system" because at least six components of the system were not present in any automobile driven before the critical date. MIT also disputes Harman's characterization of the field trials as "use" as the term "use" has a legal meaning in this context. Harman also does not identify what "third parties" it refers to. MIT also disputes any inference that Harman seeks to draw based on the number of or diversity in people who may have conducted field trials because Davis and Schmandt controlled the drivers' access to elements of the system and what

information they could possibly learn about the system from the field trials. Dr. Davis, during his deposition, testified that:

A: 'The Back Seat Driver' was <u>*always a research prototype*</u>, and I attempted to learn things from every experience I had of 'The Back Seat Driver.' Certainly in this case [referring to the General Motors field trial], I learned something important about U-turns that I might never have learned…I learned that my program would have to account for [a driver making an illegal U turn, a maneuver Dr. Davis hadn't planned for].

Exh. 10 at 31:14-23:3 (emphasis added). *See also* MIT's SOF 40, *supra.*

8. <u>**Harman's SOF 8**</u>: "There is no evidence that anyone ever signed any confidentiality agreement regarding the 1989 uses of the Back Seat Driver system, and no reason to believe that anyone did so."

<u>MIT's Response</u>

MIT disputes any inferences Harman seeks to draw from this statement. Confidentiality agreements are not dispositive on the issue of public use. Signed confidentiality agreements were not necessary because Davis and Schmandt controlled any possible dissemination of information about the Back Seat Driver by controlling the experimental environment and limiting test subjects' exposure to at most only the "driver input means" and the "voice apparatus." The field trial drivers were trusted colleagues of Davis and Schmandt or undergraduate students bound by ethical obligations with regard to the research, and drivers only drove the car during field trials with Davis or Schmandt present and by permission. MIT also disputes Harman's reference to the "Back Seat Driver system" without specifying which version of the prototypes it refers to. MIT also disputes Harman's conclusion that any field trials amounted to "use" of the "Back Seat Driver system" as the term "use" has a legal meaning in this context, and because any field trials were for experimental purposes under the complete control of the inventors, and therefore do not satisfy the public use prong of *Invitrogen*.

9. **Harman's SOF 9**: "None of the more than 50 persons who used a Back Seat Driver system on public streets prior to August, 1989, signed a confidentiality agreement."

MIT's Response

See response to Harman's SOF 8.

10. **Harman's SOF 10**: "The subject matter of claim 1 was present in the Back Seat Driver prototype 'running in prototype form since April 1989' and 'successfully used by drivers who have never driven in Boston.'"

MIT's Response

MIT does not dispute that the VNIS '89 Back Seat Driver Paper cited by Harman says "The system has been running in prototype form since April 1989. It has been successfully used by drivers who have never driven in Boston." MIT disputes the inferences Harman attempts to draw from this statement of fact. Harman fails to identify which version of the Back Seat Driver prototypes it refers to as running in prototype form in April 1989. The paper cited by Harman to support this statement of fact ("the VNIS 1989 paper") identifies the Back Seat Driver as running in "prototype form" without specifying which version of the Back Seat Driver prototype was referred to. MIT disputes Harman's conclusion that any field trials of Back Seat Driver prototypes amount to "use" of the invention of claim 1 as the term "use" has a legal meaning in this context.

11. **Harman's SOF 11**: "The subject matter of claim 1 of the '685 patent was embodied in the Back Seat Driver system used on the public streets in or around Boston in June, 1989."

MIT's Response

MIT disputes this statement of fact and inferences Harman seeks to draw from it. Harman does not specify which version of the "Back Seat Driver" prototype it refers to. MIT

disputes Harman's conclusion that field trials of the Back Seat Driver system amounted to "use" of the patented invention as the term "use" has a legal meaning in this context.

12. **<u>Harman's SOF 12</u>**: "The subject matter of claim 1 of the '685 patent was embodied in every use of the Back Seat Driver system that occurred after June 1989."

<u>MIT's Response</u>

See Response to Harman's SOF 11.

13. **<u>Harman's SOF 13</u>**: "The Back Seat Driver continued to be driven around the public streets of Boston in July, 1989."

<u>MIT's Response</u>

MIT does not dispute that field trials occurred in July 1989. However, MIT disputes any inferences Harman seeks to draw therefrom. Harman has not shown that "Version 3" of the Back Seat Driver prototype was actually used for any of the field trials in July 1989. In fact, the NEC Vehicle Navigation System (the "location system") used in "Version 3" "arrived only during the final weeks of the project…[the inventors] found several difficulties with the design and operation of the Navigation System" and the inventors indicated they would "describe these in detail in a letter to follow shortly, as part of [the] work under the Extension to the current" research sponsorship. Exh. 9 at 176.

14. **<u>Harman's SOF 14</u>**: "The subject matter recited in claim 1 of the '685 patent was embodied in a Back Seat Driver system that was used on public streets around Boston between the end of June 1989 and August 4, 1989."

<u>MIT's Response</u>

See response to Harman's SOF 13.

15. **Harman's SOF 15**: "The subject matter recited in claim 1 of the '685 patent was reduced to practice at least as early as June 1989."

MIT's Response

MIT disputes Harman's attempt to couch a legal conclusion as a fact. Whether the invention of claim 1 was "reduced to practice" is not dispositive of a statutory bar under § 102(b), which requires the invention to be "in public use" and "ready for patenting." *See Mannville Sales*, 917 F.2d at 551; *EZ Dock*, 276 F.3d at 1353. MIT has shown that the invention of claim 1 was not in public use based on the experimental circumstances surrounding field trials that occurred during the summer of 1989.

16. **Harman's SOF 16**: "Prior to uses of the Back Seat Driver system on public streets in June and July 1989, Mr. Davis already knew that the Back Seat Driver would work for its intended purpose."

MIT's Response

MIT disputes this statement of fact and inferences Harman seeks to draw from it. Both Dr. Davis and Mr. Schmandt testified that they were not "certain" the Back Seat Driver would work, but that they were "confident" that the system would work by the end of the summer. MIT's SOF 41, *supra*. MIT disputes Harman's conclusion that field trials constituted "uses" under the patented invention under § 102(b), which MIT has shown that they are not under *Invitrogen*. *See also* Response to Harman's SOF 11.

17. **<u>Harman's SOF 17</u>**: "Prior to uses of the Back Seat Driver system on public streets in June and July 1989, Mr. Davis was already publicly claiming that the Back Seat Driver was a working system."

<u>MIT's Response</u>

MIT disputes Harman's characterization of the IEEE abstract as Dr. Davis "publicly claiming that the Back Seat Driver was a working system," which is not what the document says. Harman mischaracterizes and misquotes the document on which Dr. Davis' testimony was based. The document, which is the June 1989 IEEE abstract (Docket No. 146-13), states that the system "is already working in prototype form." The "prototype form" of the Back Seat Driver that Harman appears to be referring to was "Version 2," which featured a human operator in the car and which does not embody claim 1 of the '685 patent. MIT disputes Harman's characterizations of the field trials as "uses" of the invention as the term "use" has a legal meaning in this context.

18. **<u>Harman's SOF 18</u>**: "Claim 42 claims '[t]he automobile navigation system of claim 1 wherein each intersection in a route is classified into one type in a taxonomy of intersection types, and the disclosure generated in relation to each said intersection depends on its type.'"

<u>MIT's Response</u>

MIT does not dispute this.

19. **<u>Harman's SOF 19</u>**: "In June, 1989, MIT completed and submitted for publication in the proceedings of the IEEE Vehicle Navigation and Information Systems Conference a paper entitled: 'The Back Seat Driver: Real Time Spoken Driving Instructions.'"

<u>MIT's Response</u>

MIT does not dispute this.

20. **<u>Harman's SOF 20</u>**: "The VNIS '89 Back Seat Driver Paper describes the Back Seat Driver prototype 'running in prototype form since April 1989' and 'successfully used by drivers who have never driven in Boston.'"

<u>MIT's Response</u>

MIT does not dispute that the VNIS '89 Back Seat Driver Paper says, "The system has been running in prototype form since April 1989. It has been successfully used by drivers who have never driven in Boston." However, MIT disputes any inferences Harman seeks to draw regarding the nature of the field trials, which MIT has shown were permissible experimentation and therefore, not "public use." MIT also disputes this statement insofar as Harman has failed to identify which Back Seat Driver prototype version the VNIS '89 paper refers to.

21. **<u>Harman's SOF 21</u>**: "The working prototype system described in the VNIS '89 Back Seat Driver Paper included a taxonomy of intersection types, including the intersection types enter, exit, and fork and '[t]he items in the taxonomy of intersection types are called **acts.**' (emphasis in original)."

<u>MIT's Response</u>

MIT does not dispute that the VNIS '89 Back Seat Driver Paper says, "The items in the taxonomy of intersection types are called acts." However, MIT disputes any inferences Harman seeks to draw from this statement insofar as Harman implies that the taxonomy was not changed in response to the field trials.

22. **<u>Harman's SOF 22</u>**: "The working prototype system described in VNIS '89 Back Seat Driver Paper considered every connection from one segment in a route to the next segment to be an intersection."

<u>MIT's Response</u>

MIT does not dispute that the VNIS '89 Back Seat Driver Paper says, "We consider every connection from one segment to another as an 'intersection', even if there is only one next segment at the intersection." However, MIT disputes any inferences Harman seeks to draw regarding the nature of the field trials, which MIT has shown are permissible experimentation and therefore, not "public use."

23. **<u>Harman's SOF 23</u>**: "The working prototype system described in VNIS '89 Back Seat Driver Paper relied upon the taxonomy of intersection types to describe intersections."

<u>MIT's Response</u>

MIT does not dispute that the VNIS '89 Back Seat Driver Paper says, "Based on a study of how people naturally give spoken driving instructions, we developed a taxonomy of intersection types (Figure 2). This taxonomy is necessary in order to describe an intersection in the same way that a person would." MIT disputes any inferences Harman seeks to draw regarding the nature of the field trials, which MIT has shown are permissible experimentation and therefore, not "public use." MIT disputes this statement of fact as vague insofar as it refers to the Back Seat Driver "relying" on anything.

24. **<u>Harman's SOF 24</u>**: "In the working prototype system described in VNIS '89 Back Seat Driver Paper, a corresponding expert existed for each act, which experts 'generate text which describes the intersection.'"

<u>MIT's Response</u>

MIT does not dispute that the VNIS '89 Back Seat Driver Paper says, "for each act there is a corresponding 'expert'…each expert is able to generate text which describes the intersection." However, MIT disputes any inferences Harman seeks to draw regarding the nature of the field trials, which MIT has shown are permissible experimentation and therefore, not "public use."

25. **<u>Harman's SOF 25</u>**: "The 'Direction Assistance' project was an earlier research project by Davis and Schmandt, that evolved into the 'Back Seat Driver' project that led to the '685 patent."

<u>MIT's Response</u>

MIT denies this statement of fact and inferences that Harman seeks to draw from it. Mr. Schmandt was not involved in the "Direction Assistance" work. Exh. 8 at 148:8-13 ("Direction Assistance was Jim Davis's program and has been published under his name. It [MIT1370-85] also references Grunt, which is a program that I had written and had been published under my name. Up to that point, I had, our work on these two projects was separate.") The "Direction Assistance" program is irrelevant to whether the "Back Seat Driver" was in public use, and MIT disputes Harman's attempt to equate "Direction Assistance" and "Back Seat Driver." MIT denies that "Direction Assistance" "evolved" into the "Back Seat Driver" and the inferences Harman seeks to draw therefrom. "Direction Assistance" was a static, direction-giving program; the "Back Seat Driver" was a real-time automobile navigation system. Exh. 2 at 108; Exh. 1 at

1:59-62. Moreover, Dr. Davis testified that, in addition to including elements not found in "Direction Assistance," the "discourse generator" of the "Back Seat Driver" was significantly different from "Direction Assistance". Exh. 10 at 215:6-216:5:

Q: Let me just clear this up. At the time the 'Direction Assistance' display was installed in the Boston Computer Museum, did it have a discourse generator?
MR BAUER: Objection. Undefined term. By what definition, Mr. Leavell?
Q: You can answer sir.
A: The 'Direction Assistance' program produces one kind of text. It doesn't produce real time text. It has a discourse generator, and it is a different discourse generator than 'The Back Seat Driver.'
Q: But did it have a discourse generator when it was first installed in the computer museum?
MR BAUER: Objection. An undefined term.
A: There are two kinds of discourse generators we are talking about here.
Q: Understood.
A: I think you could – from the standpoint of discourse generator as I intended it in '685, no, it didn't have a discourse generator.
Q: Why not?
A: Because it wasn't doing real time discourse. This was a different kind of discourse.

26. **<u>Harman's SOF 26</u>**: "By 1987, a Direction Assistance system was in public use at the Computer Museum in Boston, and another system was also in public use as part of the Age of Intelligent Machines exhibit traveling across the United States."

<u>MIT's Response</u>

MIT denies this fact insofar as "public use" has a legal meaning in this context. Unlike the "Direction Assistance" program, the "Back Seat Driver" system was never displayed at the Boston Computer Museum, any other museum, or as part of the Age of Intelligent Machines exhibit. As such, nothing about any display at the Boston Computer Museum of "Direction Assistance" can support an inference that the *<u>Back Seat Driver</u>* was in the public domain or that the public would reasonably believe that it was. The "Direction Assistance" program is irrelevant to whether the "Back Seat Driver" itself, as embodied in the claims of the '685 patent, was in public use, and MIT disputes Harman's attempt to equate "Direction Assistance" and

"Back Seat Driver." *See also* Response to Harman's SOF 25.

27. **Harman's SOF 27**: "The following subject matter was present in a Direction Assistance system that was in public use in 1987:

- A taxonomy of intersection types, including at least the following intersection types: enter, exit, and fork.
- Breaking down a route into a 'sequence of *acts* to be taken in following the path.'
- 'For each act...a corresponding routine which generates one to three sentences describing it.'
- A taxonomy of turns, a taxonomy of intersection types, and generating discourse in relation to each intersection depending on the type of intersection."

MIT's Response

See response to Harman's SOF 26. MIT does not dispute that the "Direction Assistance" paper "shows our taxonomy of acts," or that the "Direction Assistance" paper says, "The output of the Route Finder is a *path*…The Describer creates a new representation of the route, instead of using the path itself…The Describer's structure is a *tour*, which is a sequence of *acts* to be taken in following the path," and, "For each act there is a corresponding routine which generates one to three sentences describing it." Dr. Davis clarified, and Harman omits, during his deposition testimony:

Q: And as the 'Direction Assistance' was installed in the Boston computer museum, the taxonomy of intersection types included continue, forced turn, U-turn, enter, exit, onto rotary, stay on rotary, exit rotary, fork, turn and stop, correct?
A: Are you reading from the 'Direction Assistance' paper?
Q: I read that from claim 43 of the patent.
A: Okay. Without checking more carefully, it's difficult to say. The taxonomy did change over time as I learned better how turns ought to be described. So I could not testify under oath that the taxonomy was identical in those two systems. In fact, I would be more inclined to testify that they changed.

Exh. 10 at 229:12-230:3. *See also* Response to Harman's SOF 25.

28. **Harman's SOF 28**: "On April 27, 2006, MIT admitted that the subject matter of claim 42 was reduced to practice 'at least as early as June 1989,' noting that '[t]he details of the reduction to practice were fully described in answer to numerous questions to the inventors propounded during the deposition testimony' of the named inventors, and that 'those [deposition] answers are herein incorporated by reference' into MIT's interrogatory response."

MIT's Response

MIT does not dispute that MIT supplemented its discovery responses on April 27, 2006, but disputes any inferences Harman seeks to draw from this statement of fact. MIT disputes Harman's paraphrasing and mischaracterization of MIT's discovery responses.

29. **Harman's SOF 29**: "On May 2, 2006, MIT provided a supplemental interrogatory response, again admitting that claim 42 was reduced to practice 'at least as early as June 1989.' In this supplemental response, MIT cited to nearly 600 pages of documentation and nearly 60 pages of inventor deposition testimony to support its response."

MIT's Response

MIT does not dispute that MIT supplemented its discovery responses on May 2, 2006, but disputes any inferences Harman seeks to draw from this statement of fact. MIT disputes Harman's paraphrasing and mischaracterization of MIT's discovery responses.

30. **Harman's SOF 30**: "Included within the documents MIT cited on May 2, 2006 as supporting its admission that claim 42 was reduced to practice 'at least as early as June 1989' were MIT 933-937, MIT 938-42, MIT 1101-02, MIT 2245-54, MIT 2255-63 and MIT 2264-74. Each of these papers describes a working system at least as early as June 1989, and several describe a working system by that time that includes the subject matter of claim 42:

- MIT 00938 (VNIS '89 Back Seat Driver Paper) notes that 'The system has been running in prototype form since April 1989 ... and [t]his paper describes the strategies employed by the Back Seat Driver to successfully use speech.' The system is described as relying on a taxonomy of acts, or intersection types. MIT 00938. The text generated depends on the intersection type. MIT 00939.
- MIT 02245 ('Abstract') notes that '[t]his paper describes the strategies employed by the Back Seat Driver to successfully use speech.' MIT 02245. 'The system has been running in prototype form since April 1989. It has been successfully used by drivers who have never driven in Boston.' MIT 02246. The system is described in this document as relying on a taxonomy of acts, or intersection types. MIT 02247. The text generated depends on the intersection type. MIT 02248.
- MIT 02264 describes 'Direction Assistance' as 'an interactive program that provides spoken directions for automobile travel' and further describes its reliance on a taxonomy of acts, including the intersection types enter, exit and fork, and how text is generated accordingly for each act. MIT 02264, 68-70.
- MIT 02255 'A Voice Interface To A Direction Giving Program' describes Direction Assistance as 'a program which provides high quality directions for driving between two points in the Boston area.' MIT 02255. The Direction Assistance system is described as relying on 'a sequence of actions.' MIT 02260.
- MIT 00933 'Synthetic Speech for Real Time Direction-Giving,' notes: '[a]t the time of this writing (June 1989) we have a working system on the road' and describing the system as generating 'a series of travel segments ... separated by decision points.' MIT 00935.

- MIT 01101 ('Synthetic Speech For Real Time Direction-Giving') notes that '[t]he Back Seat Driver is already working in prototype form.'"

MIT's Response

MIT does not dispute that MIT supplemented its discovery responses on May 2, 2006, but disputes any inferences Harman seeks to draw from this statement of fact. MIT also disputes Harman's reliance upon statements made in papers authored by Davis and/or Schmandt that do not identify which version of a Back Seat Driver prototype is referred to in the papers. MIT also disputes any inferences Harman seeks to draw from its reliance on papers relating to the "Direction Assistance" program, which is a static, direction-giving program and is not a real-time automobile navigation system like "Back Seat Driver." MIT also disputes any inferences Harman seeks to draw from Direction Assistance, which is irrelevant. MIT also disputes mischaracterizations of the documents relied upon and Harman's characterization of the papers as "describing" a "working system."

31. **Harman's SOF 31**: "Included within the inventor testimony MIT cited on May 2, 2006 as supporting its interrogatory response that claim 42 was reduced to practice 'at least as early as June 1989' were pages 81-82 and pages 228-229 of Davis' deposition transcript, which respectively discuss an article written in June, 1989 that describes the Back Seat Driver ('Synthetic Speech For Real Time Direction-Giving' (MIT 933-37)), and the Direction Assistance program installed in the Boston Computer Museum in 1987, which included a taxonomy of intersection types used to generate discourse."

MIT's Response

See Response to Harman's SOF 30.

32. **Harman's SOF 32**: "On June 16, 2006, MIT amended its response to Interrogatory No. 14 to contend that the subject matter of claim 42 was reduced to practice on August 4, 1989. The only additional evidence cited by MIT to support this change in position (beyond the evidence cited in its earlier response, which said claim 42 was reduced to practice 'at least as early as June 1989') was Mr. Schmandt's 30(b)(6) deposition testimony."

MIT's Response

MIT does not dispute that on June 16, 2006, MIT amended its response to Interrogatory No. 14 but disputes any inferences Harman seeks to draw from this statement of fact.

33. **Harman's SOF 33**: "During his 30(b)(6) deposition testimony, Schmandt testified as MIT's 30(b)(6) witness that he did not know when the subject matter of claim 42 was reduced to practice. The reason Mr. Schmandt gave for not knowing whether claim 42 was reduced to practice 'at least as early as June 1989,' as MIT has previously stated in its response to Interrogatory No. 14, was that 'we have no documentation that tells us when those features were added to the system.' However, as shown above in SOF 30 and 31, documents cited by MIT demonstrate that the subject matter of claim 42 was reduced to practice at least as early as June 1989 (if not by April 1989) as admitted by MIT in its prior interrogatory responses."

MIT's Response

MIT disputes this statement of fact. Harman mischaracterizes MIT's Rule 30(b)(6) testimony, which did not involve the legal conclusion of whether the invention of claim 42 was "reduced to practice." Mr. Schmandt testified that the subject matter of claim 42 was implemented at least as early as August 4, 1989. Moreover, as MIT's Rule 30(b)(6) witness, Mr. Schmandt testified that the version of the Back Seat Driver embodied in Dr. Davis' thesis on August 4, 1989, included the subject matter of claim 42. Exh. 11 at 58:18-59:6:

Q: We've marked as 92, your handwritten list. And what that indicates is which claims were present in the Back Seat Driver as it existed as an actual working prototype as of August 4th, 1989, and had by that time successfully guided drivers unfamiliar to Cambridge to their destinations. Those claims that fall within that are listed as Yes on your list; is that correct?
A: That's correct.
Q: And which claims are those, according to your list?
A: … 40 through 49 inclusive….

Moreover, MIT clarified that the features of claims 42 and 45 were not necessarily present in the "Direction Assistance" program. Exh. 11 at 72:6-23:

Q: Right. The question is: Did the Back Seat Driver, as it existed as a working prototype in field trials in June of 1989, include the subject matter of Claims 42 through 49?
A: We don't know.
Q: Why not?
A: Because we have no documentation that tells us when those features were added to the system.
Q: If those features were included in the database of the Direction Assistance Program, is it reasonable to assume they were carried over to the Back Seat Driver system?
MS. MOTTLEY: Same objections.
A: No, it is not.
Q: Why not?
MS. MOTTLEY: Same objections.
A: Because these aren't – these claims don't apply to databases. They apply to what's spoken.

34. **<u>Harman's SOF 34</u>**: "Claim 45 claims '[t]he automobile navigation system of claim 1 wherein said discourse generated comprises a long description of an act given substantially before the act is to be performed and a short description given at the time the act is to be performed.'"

<u>MIT's Response</u>

MIT does not dispute this.

35. **<u>Harman's SOF 35</u>**: "The subject matter of claim 45 was present in a Back Seat Driver prototype 'running in prototype form since April 1989' and 'successfully used by drivers who have never driven in Boston.' In particular, the VNIS '89 Back Seat Driver Paper describes 'the strategies employed by the Back Seat Driver to successfully use speech' including, at least under

MIT's construction, the subject matter of claim 45 of the '685 patent. For example:

- This prototype system included the limitations of dependant claim 1 [*sic*] as discussed above.
- This working prototype further gave 'instructions just prior to the action. It also gives instructions further in advance, if time permits.'
- The prototype 'gives the instructions twice, first in a detail, and later in a brief form.'"

MIT's Response

MIT disputes this statement of fact and any inferences Harman seeks to draw from this statement of fact. MIT disputes this statement of fact insofar as the claims have not yet been construed. MIT disputes Harman's claim that "the prototype system included the limitation of [independent] claim 1 as discussed above," which Harman has not shown.

36. **Harman's SOF 36**: "On April 27, 2006, MIT admitted that the subject matter of claim 45 was reduced to practice 'at least as early as June 1989,' again noting that 'the details of the reduction to practice were fully described in answer to numerous questions to the inventors propounded during the deposition testimony' of the named inventors, and that 'those [deposition] answers are herein incorporated by reference' into MIT's interrogatory response."

MIT's Response

MIT does not dispute that MIT supplemented its discovery responses on April 27, 2006, but disputes any inferences Harman seeks to draw from this statement of fact.

37. **<u>Harman's SOF 37</u>**: "On May 2, 2006, MIT provided a supplemental interrogatory response, which re-iterated that claim 45 was reduced to practice 'at least as early as June 1989.' In this supplemental response, MIT cited to nearly 600 pages of documentation and nearly 60 pages of inventor deposition testimony to support its response."

<u>MIT's Response</u>

MIT does not dispute that MIT supplemented its discovery responses on May 2, 2006, but disputes any inferences Harman seeks to draw from this statement of fact.

38. **<u>Harman's SOF 38</u>**: "Included within the documents MIT cited on May 2, 2006 as supporting its interrogatory response that claim 45 was reduced to practice 'at least as early as June 1989' were MIT 933-937, MIT 938-42, MIT 1101-02, and MIT 2245-54. Each of these papers describes the working prototype:

- MIT 00933-37 'Synthetic Speech for Real Time Direction-Giving,' notes: '[a]t the time of this writing (June 1989) we have a working system on the road'
- MIT 00938-42 (VNIS '89 Back Seat Driver Paper) 'The Back Seat Driver: Real Time Spoken Driving Instructions' noting that '[t]he system has been running in prototype form since April 1989 ... and [t]his paper describes the strategies employed by the Back Seat Driver to successfully use speech.' This paper also notes '... the program gives the instruction twice, first in a detail, and later in a brief form.'
- MIT 01101-01102 'Synthetic Speech For Real Time Direction-Giving' noting that '[t]he Back Seat Driver is already working in prototype form.'
- MIT 02245 'Abstract' noting that '[t]his paper describes the strategies employed by the Back Seat Driver to successfully use speech.' MIT 02245. 'If the time between instructions is long, the program gives the instruction twice, first in a detail and later in a

brief form.' MIT 02246. 'The system has been running in prototype form since April 1989. It has been successfully used by drivers who have never driven in Boston.'"

MIT's Response

MIT does not dispute that MIT supplemented its discovery responses on May 2, 2006, but disputes any inferences Harman seeks to draw from this statement of fact. MIT disputes Harman's characterization of the papers as "describing" a "working system" or "working prototype" without demonstrating which version of the Back Seat Driver.

39. **Harman's SOF 39**: "On June 16, 2006 MIT amended its response to Interrogatory No. 14 to contend that the subject matter of claim 45 was not reduced to practice until August 4, 1989. As true of claim 42, in support of its change of position, the only additional evidence cited by MIT (beyond that already cited in its earlier response, which said claim 45 was reduced to practice 'at least as early as June 1989') was Mr. Schmandt's 30(b)(6) deposition testimony. However, Mr. Schmandt testified under oath as MIT's 30(b)(6) that he did not know whether or not the subject matter of claim 45 was already reduced to practice as least as early as June 1989. The reason Mr. Schmandt gave for not knowing whether claim 45 was reduced to practice 'at least as early as June 1989,' as MIT has previously stated in its response to Interrogatory No. 14, was that 'we have no documentation that tells us when those features were added to the system.' However, as shown above in Facts 35 and 38 above, documents do tell us that the subject matter of claim 45 was present in the system at least as early as June 1989."

MIT's Response

MIT does not dispute that on June 16, 2006, MIT amended its response to Interrogatory No. 14. MIT disputes Harman's implication that MIT changed or amended its discovery responses in responses to invalidity positions forwarded by Harman. Harman mischaracterizes

MIT's Rule 30(b)(6) testimony, which did not involve the legal conclusion of whether the invention of claim 45 was "reduced to practice."

40. **Harman's SOF 40**: "At the time of the Back Seat Driver project, MIT had a written policy entitled 'Open Research and the Free Interchange of Information,' which touted 'the profound merits of a policy of open research and free interchange of information among scholars as essential to that responsibility and to the interests of the nation as a whole.'"

MIT's Response

MIT disputes Harman's reliance on a document that does not specifically relate to the Back Seat Driver research program or the expectations of the research sponsor, which expected the research to be kept "close to the vest." Exh. 22 at 303:3-8.

41. **Harman's SOF 41**: "At the time of the Back Seat Driver project, the MIT Media Lab had a written policy that 'the Media Laboratory is an intellectually open environment where ideas are readily exchanged.'"

MIT's Response

See Response to Harman's SOF 40.

42. **Harman's SOF 42**: "(Tab 6, MIT 01101-02) is a true and correct copy of a printed article entitled 'Synthetic Speech for Real time Direction-Giving,' authored by Davis and Schmandt ('the June 1989 Back Seat Driver Paper')."

MIT's Response

MIT does not dispute that MIT1101-02 was authored by Davis and Schmandt. MIT does dispute Harman's characterization of MIT1101-02 as a "printed article" or a "paper." MIT1101-02 is an abstract of an article that appeared later in 1989 than the abstract ("the June 1989 abstract").

43. **Harman's SOF 43**: "The June 1989 Back Seat Driver Paper was presented at the June 6-9 International Conference on Consumer Electronics, in Rosemont, Illinois. The conference presentation and paper were not subject to any confidentiality obligation or restriction."

MIT's Response

See Response to Harman's SOF 42. MIT disputes any inferences Harman seeks to draw from this statement insofar as it implicates "confidentiality obligation[s] or restriction[s]," which are not determinative of "public use."

44. **Harman's SOF 44**: "The June 1989 Back Seat Driver Paper was made available and provided to attendees at the International Conference on Consumer Electronics, as pages 288-289 of a larger collection of presentation materials."

MIT's Response

See Response to Harman's SOF 42.

45. **Harman's SOF 45**: "The June 1989 Back Seat Driver Paper notes that uses of the Back Seat Driver were taking place on the public streets of Boston."

MIT's Response

See Response to Harman's SOF 42. MIT does not dispute that the June 1989 abstract says, "The Back Seat Driver is a research prototype of a system to use speech synthesis as a navigational aid for an automobile equipped with localization equipment. We are evaluating the user interface by field trials." The text of the June 1989 abstract indicates that the prototype was not a finished system and "field trials" were being conducted to test the user interface. MIT disputes this statement insofar as Harman has not shown which version of the Back Seat Driver it refers to.

46. **Harman's SOF 46**: "The June 1989 Back Seat Driver Paper publicized several aspects of the system. Specifically:

- The June 1989 Back Seat Driver Paper described an automobile navigation system which produces spoken instructions to direct a driver of an automobile to a destination in real time.
- The June 1989 Back Seat Driver Paper described computing apparatus (a Symbolics Lisp computer) for running and coordinating system processes.
- The June 1989 Back Seat Driver Paper described driver input (a cellular telephone keypad)
- The June 1989 Back Seat Driver Paper described a map database connected to the computing apparatus which was extended to explicitly represent legal connectivity
- The June 1989 Back Seat Driver Paper described a position sensing apparatus installed in the automobile and connected to the computing apparatus for providing the computing apparatus data for determining the automobile's current position.
- The June 1989 Back Seat Driver Paper described a location system connected to the computing apparatus for accepting data from said position sensing apparatus and for determining the automobile's current position relative to the map database.
- The June 1989 Back Seat Driver Paper described a route-finder connected to the computing apparatus for computing a route to the destination.
- The June 1989 Back Seat Driver Paper described a 'real-time system' which generated instructions spoken by a speech synthesizer deciding what to say by comparing the current position against the map. The system delivered 'instructions at the proper place and in a timely manner.'

- The June 1989 Back Seat Driver Paper described '[t]he generation of easy followed natural descriptions' through the use of 'a number of new segment types to distinguish bridges, underpasses, tunnels, rotaries, and access ramps,' which was done from the earlier Direction Assistance project. As noted and supported in Fact No. 28, in the Direction Assistance project, intersections in a route were classified into one type in a taxonomy of intersection types, and the discourse generated in relation to each said intersection depended on its type.
- The June 1989 Back Seat Driver Paper described a speech generator connected to said discourse generator for generating speech from said discourse provided by said discourse generator.
- The June 1989 Back Seat Driver Paper described voice apparatus connected to said speech generator for communicating said speech provided by said speech generator to said driver."

MIT's Response

MIT does not dispute that the June 1989 abstract says "The Back Seat Driver is a research prototype of a system to use speech synthesis as a navigational aid for an automobile equipped with localization equipment. We are evaluating the user interface by field trials." The June 1989 abstract is an abstract and not a "paper" or "printed article." MIT also disputes the inference Harman seeks to draw that the conference proceedings made the Back Seat Driver "accessible to the public" or "in the public domain." The text of the June 1989 abstract indicates that the prototype was not a finished system and "field trials" were being conducted to test the user interface. MIT disputes Harman's attempt to read claim 1 on the June 1989 abstract as claim 1 has yet to be construed by the Court, and if Harman's proposed constructions are

adopted, then claim 1will not read on the June 1989 abstract.

47. **Harman's SOF 47**: "MIT's own internal Technology Licensing Office forms confirm that a 'Public Disclosure' of the Back Seat Driver occurred on June 9, 1989 at the IEEE International Conference on Consumer Electronics."

MIT's Response

MIT disputes this statement of fact and inferences Harman seeks to draw from it. MIT disputes this statement of fact insofar as it implies the forms were addressing a legal conclusion regarding "public disclosure." It is undisputed that the Back Seat Driver research prototypes were not presented at the conference.

48. **Harman's SOF 48**: "An article entitled 'Prototype Guidance Unit Uses Synthetic Speech' was published in *Automotive Electronic News* on July 17, 1989. This article discusses the 'prototype guidance system' which 'gives directions in real time' and includes interview comments from Schmandt, a block diagram provided by the MIT Media Lab, and an example of the text generated by the system at the time."

MIT's Response

MIT does not dispute that an article titled "Prototype Guidance Unit Uses Synthetic Speech" appeared in an issue of *Automotive Electronic News* dated July 17, 1989 or that the articles says: "The next step in the Back Seat Driver's development, according to the researchers, is to determine exactly what a speech guidance system should say, how time and vehicle speed affect the instruction it gives, and what features a map database must have to support the generation of useful spoken instructions." MIT disputes Harman's statement of fact and reliance upon statements made in the July 17, 1989 paper that do not identify which version of a Back Seat Driver prototype is referred to. MIT also disputes Harman's characterization of

"the 'prototype system.'"

49. **<u>Harman's SOF 49</u>**: "NEC, the corporate sponsor for the Back Seat Driver project, attended 'regular quarterly meetings' with MIT, at which NEC 'would see everything that [MIT] had', 'would have seen whatever they wanted' 'would have seen the system in its current state of operation,' and 'would have seen the software.'"

<u>MIT's Response</u>

MIT does not dispute that NEC sponsored the Back Seat Driver research. MIT disputes the fact that NEC "attended" "regular quarterly meetings."

50. **<u>Harman's SOF 50</u>**: "MIT did not implement a confidentiality arrangement with NEC."

<u>MIT's Response</u>

MIT disputes this statement of fact as vague insofar as it refers to an arrangement being "implemented." MIT also disputes any inferences Harman attempts to draw from this statement because confidentiality agreements or arrangements are not dispositive of the "public use" issue. Formal confidentiality obligations were not necessary between NEC and the inventors because an implied confidentiality obligation existed between MIT and NEC. Exh. 22 at 303:3-8.

51. **<u>Harman's SOF 51</u>**: "Mr. Rittmueller (of NEC) was under no obligation to keep the Back Seat Driver project confidential."

<u>MIT's Response</u>

See Response to Harman's SOF 50.

52. **<u>Harman's SOF 52</u>**: "Mr. Rittmueller was present at 'probably two or three' demonstrations of the Back Seat Driver."

<u>MIT's Response</u>

See Response to Harman's SOF 50.

53. **Harman's SOF 53**: "The MIT Media Lab had a relationship with Bellcore such that Bellcore employees 'would know what was basically going on on projects.' MIT sent reports, abstracts and 'videotapes of current projects.' Mr. Lesk provided at least one Bellcore employee a 'running commentary' on the work on the Back Seat Driver. At least one abstract sent to Bellcore described the Back Seat Driver."

MIT's Response

MIT disputes this statement of fact and any inferences Harman seeks to draw from it insofar as "relationship" is vague and ambiguous. Harman alleges no dates on which any of these alleged facts occurred. MIT disputes the relevance of this statement because reports, abstracts, or videotapes do not amount to public use of the invention. The Bellcore employees identified by Harman, Mike Lesk and Lynn Streeter, recognized an implied duty of confidentiality recognized by professional academic colleagues. Exh. 26 at ¶¶ 3-4, 7-8. Lesk was on Davis' thesis committee and, therefore, would be expected to know the status of Davis' thesis research. Exh. 2 at 5.

54. **Harman's SOF 54**: "At least one Bellcore researcher, Lynn Streeter, received a detailed, 18-page thesis proposal describing the Back Seat Driver project, dated January 1, 1989."

MIT's Response

MIT disputes any inferences Harman seeks to draw from this statement of fact. Harman has not shown when Lynn Streeter received the thesis proposal, and an equally valid inference is that Dr. Streeter received the proposal after the critical date. Dr. Streeter understood an implied duty of confidentiality recognized by professional academic colleagues. Exh. 26 at ¶¶ 3-4, 7-8.

55. **Harman's SOF 55**: "At least one Bellcore employee, Michael Lesk, visited the Media Lab 'all the time' to discuss current projects at the Media Lab with the MIT faculty."

MIT's Response

See Response to Harman's SOF 53.

56. **Harman's SOF 56**: "On at least one trip to the Media Lab, Mr. Lesk was shown the Back Seat Driver system. Mr. Lesk shared what he had learned about the Back Seat Driver with others at Bellcore without requiring any confidentiality."

MIT's Response

See Response to Harman's SOF 53. Harman has failed to show how this statement of fact relates in any way to the subject matter of its Invalidity Motion, and MIT disputes its relevance. A demonstration of a Back Seat Driver prototype to Mike Lesk, one of Davis' thesis advisors, would not amount to a public use of the invention or lead the public to reasonably believe the invention was in the public domain.

57. **Harman's SOF 57**: "Bellcore personnel freely shared reports from MIT's Media Lab."

MIT's Response

See Response to Harman's SOF 53. MIT disputes this statement of fact and any inferences Harman seeks to draw from it. Harman has not shown that Bellcore personnel ever shared MIT reports with anyone outside of Bellcore or MIT. Harman has failed to show how this statement of fact relates in any way to the subject matter of its Invalidity Motion or the Back Seat Driver, and MIT disputes its relevance.

58. **Harman's SOF 58**: "MIT is a private corporation, with fiscal years and published financial data. For Fiscal Year 2006, 'Sponsored research' accounted for 47.5% of MIT's 'Operating Expenditures' or $1.03 billion."

MIT's Response

MIT does not dispute this irrelevant fact, but MIT disputes any inference Harman

attempts to draw from it. The fact that MIT is a corporation does not lead to an inference that the Back Seat Driver research was commercially exploited. Harman has not shown how this statement is relevant to the MIT Media Lab, which is where the Back Seat Driver research occurred. Harman has not shown how this statement is relevant to the Back Seat Driver research, which occurred over ten years before the statistic cited in this statement.

59. **Harman's SOF 59**: "MIT publishes a document entitled 'How to Get Value from Media Lab Sponsorships' that notes that sponsors of the Media Lab are entitled to 'visit, view, and discuss' 'hundreds of working prototypes developed at the Lab,' encourages sponsors to 'visit the Lab during the year for individual discussions and demonstrations,' notes that sponsors are given access to a sponsors-only website that 'consolidates technical notes on research projects,' and encourages sponsors to use 'the Lab as a window to investments and start- ups' in order to get "an inside track on potential opportunities.'"

MIT's Response

Harman has failed to show how this statement of fact applied to the Back Seat Driver research or whether this policy was even in place when the Back Seat Driver research was occurring. Harman has not shown that the policies embodied in this document specifically applied to the Back Seat Driver research or research prototypes.

60. **Harman's SOF 60**: "NEC provided at least $400,000 to fund the Back Seat Driver project. MIT referred to NEC as a 'customer' and one who was 'particularly generous.'"

MIT's Response

MIT does not dispute that NEC provided money to sponsor the Back Seat Driver research. MIT disputes any inference Harman seeks to draw from this statement of fact. MIT also disputes Harman's mischaracterization of internal Media Lab correspondence and that this

statement of fact as relevant to any issue in Harman's Invalidity Motion. Harman has not shown that NEC was a "customer" in the traditional sense of a commercial offer for sale or contract because NEC would be an eventual licensee of the Back Seat Driver technology.

61. **Harman's SOF 61**: "In the 1988-89 time frame, MIT provided information about its research projects, including the Back Seat Driver project, as a way to generate interest from potential sponsors of the Media Lab."

MIT's Response

MIT disputes the relevance of this fact. Harman has not shown to whom such information was provided.

62. **Harman's SOF 62**: "The Direction Assistance System produced spoken instructions for directing a driver of an automobile to a destination."

MIT's Response

MIT disputes this fact and any inferences Harman seeks to draw from it. "Direction Assistance" did not provide directions to a driver of an automobile -- it provided a stationary caller with a complete list of turn-by-turn instructions, like Mapquest, to a destination. Harman's characterization of Direction Assistance implies that Direction Assistance was a navigation system, which it was not. MIT also disputes this fact as irrelevant to the Back Seat Driver, which was an automobile navigation system that provided instructions generated according to a discourse model in real time. The "Direction Assistance" program is irrelevant to whether the "Back Seat Driver" was in public use, and MIT disputes Harman's attempt to equate "Direction Assistance" and "Back Seat Driver." "Direction Assistance" was a static, direction-giving program; the "Back Seat Driver" was a real-time automobile navigation system. Exh. 2 at 108; Exh. 1 at 1:59-62. Moreover, Dr. Davis testified that, in addition to including elements

not found in "Direction Assistance," the "discourse generator" of the "Back Seat Driver" was significantly different from "Direction Assistance". Exh. 10 at 215:6-216:5.

63. **<u>Harman's SOF 63</u>**: "The Direction Assistance System included computing apparatus for running and coordinating system processes."

<u>MIT's Response</u>

MIT does not dispute that Direction Assistance used a computing apparatus, but MIT disputes any inference Harman seeks to draw therefrom. The computing apparatus of Direction Assistance was not the same computing apparatus used in the Back Seat Driver prototypes. *See also* Response to Harman's SOF 62.

64. **<u>Harman's SOF 64</u>**: "The Direction Assistance System included input means (a telephone keypad) functionally connected to the computing apparatus for entering a desired destination."

<u>MIT's Response</u>

MIT does not dispute that Direction Assistance used a telephone keypad, but MIT disputes any inference Harman seeks to draw therefrom. The term "input means" has been submitted to the Court for *Markman* construction, and Harman cannot show that under the definition proposed by Harman, Direction Assistance had an input means. *See also* Response to Harman's SOF 62.

65. **<u>Harman's SOF 65</u>**: "The Direction Assistance System included a map database functionally connected to the computing apparatus and which distinguished between physical and legal connectivity."

<u>MIT's Response</u>

MIT does not dispute that Direction Assistance used a map database, but MIT disputes

any inference Harman seeks to draw therefrom. The term "map database…which distinguished between physical and legal connectivity" has been submitted to the Court for *Markman* construction, and Harman cannot show that under the definition proposed by Harman, Direction Assistance used such a database. *See also* Response to Harman's SOF 62.

66. **Harman's SOF 66**: "The Direction Assistance System included a route-finder functionally connected to the computing apparatus for accepting the desired destination from the input means, for consulting the map database, and for computing a route to the destination."

MIT's Response

MIT does not dispute that Direction Assistance included a route-finder, but MIT disputes any inference Harman seeks to draw therefrom. The term "consulting" has been submitted to the Court for *Markman* construction, and Harman cannot show that under the definition proposed by Harman, the Direction Assistance route-finder consulted the database. MIT also disputes Harman's attempt to characterize the route-finder of claim 1 of the '685 patent without including the rest of the language from that element of claim 1, including "for accepting the current position from the location system," because the Direction Assistance product did not accept a current position from any location system. *See also* Response to Harman's SOF 62.

67. **Harman's SOF 67**: "The Direction Assistance System included a module functionally connected to the computing apparatus, for accepting the route from the route finder, and for composing discourse, including instructions for directing someone to their desired destination."

MIT's Response

MIT does not dispute that Direction Assistance included a module for composing static-instruction-type directions but MIT disputes any inference Harman seeks to draw therefrom. MIT disputes Harman's attempt to characterize this module as a "discourse generator" recited by

claim 1 of the ’685 patent. The term “discourse generator” as it is used in the ’685 patent has been submitted to the Court for *Markman* construction wherein the term refers to real-time dialogue according to a discourse model, and Harman cannot show that under the definition proposed by MIT or Harman, that Direction Assistance composed discourse. Harman’s characterization of Direction Assistance implies that Direction Assistance was a navigation system, which it was not. “Direction Assistance” was a static, direction-giving program; the “Back Seat Driver” was a real-time automobile navigation system. Exh. 2 at 108; Exh. 1 at 1:59-62. Dr. Davis testified that although what Direction Assistance generated could be called “discourse,” the discourse generator of the “Back Seat Driver” was significantly different from “Direction Assistance”. Exh. 10 at 215:6-216:5:

Q: Let me just clear this up. At the time the ‘Direction Assistance’ display was installed in the Boston Computer Museum, did it have a discourse generator.
MR BAUER: Objection. Undefined term. By what definition, Mr. Leavell?
Q: You can answer sir.
A: The ‘Direction Assistance’ program produces one kind of text. It doesn’t produce real time text. It has a discourse generator, and it is a different discourse generator than ‘The Back Seat Driver.’
Q: But did it have a discourse generator when it was first installed in the computer museum?
MR BAUER: Objection. An undefined term.
A: There are two kinds of discourse generators we are talking about here.
Q: Understood.
A: I think you could – from the standpoint of discourse generator as I intended it in ‘685, no, it didn’t have a discourse generator.
Q: Why not?
A: Because it wasn’t doing real time discourse. This was a different kind of discourse.

See also Response to Harman’s SOF 62.

68. **Harman's SOF 68**: "In the discourse generated by the Direction Assistance System, intersections in a route were classified into one type in a taxonomy of intersection types, and the discourse generated in relation to each said intersection depended on its type."

MIT's Response

See Response to Harman's SOF 67.

69. **Harman's SOF 69**: "The Direction Assistance System included a speech generator (a DecTalk speech synthesizer) that generated speech from the module that composed the discourse."

MIT's Response

MIT does not dispute this but does dispute any inferences Harman seeks to draw from this fact because Direction Assistance was irrelevant to Back Seat Driver. *See also* Response to Harman's SOF 62.

70. **Harman's SOF 70**: "The Direction Assistance System included voice apparatus (a speaker) functionally connected to the speech synthesizer for communicating the speech to the user."

MIT's Response

See Response to Harman's SOF 69.

71. **Harman's SOF 71**: "The location system used in the Back Seat Driver project was a unit acquired by Davis and Schmandt from NEC."

MIT's Response

MIT does not dispute this but does dispute any inferences Harman seeks to draw from this fact, including an inference that inventors are not allowed patent inventions that in some way involve components that happen to be available, which is contrary to well-established law.

See City of Elizabeth v. Am. Nicholson Paving Co., 97 U.S. 126, 129-130 (1877).

72. **Harman's SOF 72**: "The NEC location system that was used in the Back Seat Driver is described in a 1988 publication."

MIT's Response

MIT does not dispute that NEC provided a dead reckoning system for use in the Back Seat Driver but disputes Harman's characterization of the NEC device as the "location system" and the 1988 publication as "describ[ing]" the "location system." *See also* Response to Harman's SOF 71. Mr. Schmandt's deposition testimony stands on its own.

73. **Harman's SOF 73**: "Davis and Schmandt had nothing to do with the design or implementation of the location finding hardware for the Back Seat Driver system."

MIT's Response

MIT does not dispute that NEC provided location-finding hardware. MIT does dispute Harman's mischaracterization that "Davis and Schmandt had nothing to do with the design or implementation of the location finding hardware for the Back Seat Driver system." Davis and Schmandt interfaced the NEC system to the working Back Seat Driver system and were required to do substantial work to get the systems co-operational. Exh. 9 at 173. *See also* Response to Harman's SOF 71.

74. **Harman's SOF 74**: "The speech generator used in the Back Seat Driver project was an off-the-shelf speech synthesizer, called a DecTalk, that could be purchased at the time (at least as early as 1987) from Digital Equipment Corporation."

MIT's Response

MIT does not dispute that DEC made the speech synthesizer system. *See also* Response to Harman's SOF 71.

August 30, 2007

Respectfully Submitted,

Massachusetts Institute of Technology,
By its Attorneys,

/s/ Steven M. Bauer

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CERTIFICATE OF SERVICE

I certify that on August 30, 2007, I caused a copy of the forgoing document to be served upon counsel of record for Harman International Industries by the Court's ECF system.

/s/ Steven M. Bauer
Steven M. Bauer

EXHIBIT 1

US005177685A

United States Patent [19]

Davis et al.

[11] **Patent Number: 5,177,685**

[45] **Date of Patent: Jan. 5, 1993**

[54] **AUTOMOBILE NAVIGATION SYSTEM USING REAL TIME SPOKEN DRIVING INSTRUCTIONS**

[75] Inventors: **James R. Davis**, North Cambridge; **Christopher M. Schmandt**, Milton, both of Mass.

[73] Assignee: **Massachusetts Institute of Technology**, Cambridge, Mass.

[21] Appl. No.: **565,274**

[22] Filed: **Aug. 9, 1990**

[51] **Int. Cl.**[5] **G01C 21/00**

[52] **U.S. Cl.** **364/443**; 340/988; 364/449; 364/453

[58] **Field of Search** 340/988, 989, 990, 995; 364/443, 444, 449, 450, 453, 436

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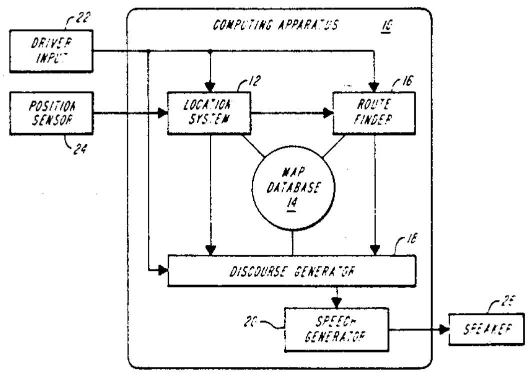
Primary Examiner—Parshotam S. Lall
Assistant Examiner—Edward Pipala
Attorney, Agent, or Firm—Choate, Hall & Stewart

[57] **ABSTRACT**

An automobile navigation system which provides spoken instructions to the driver of an automobile to guide the driver along a route is disclosed. The heart of the system is a computing apparatus comprising a map database, route finding algorithms, a vehicle location system, discourse generating programs, and speech generating programs. Driver input means allows the driver to enter information such as a desired destination. The route finding algorithms in the computer apparatus calculate a route to the destination. The vehicle location system accepts input from a position sensor which measures automobile movement (magnitude and direction) continuously, and using this data in conjunction with the map database, determines the position of the automobile. Based on the current position of the automobile and the route, the discourse generating programs compose driving instructions and other messages according to a discourse model in real time as they are needed. The instructions and messages are sent to voice generating apparatus which conveys them to the driver.

58 Claims, 3 Drawing Sheets



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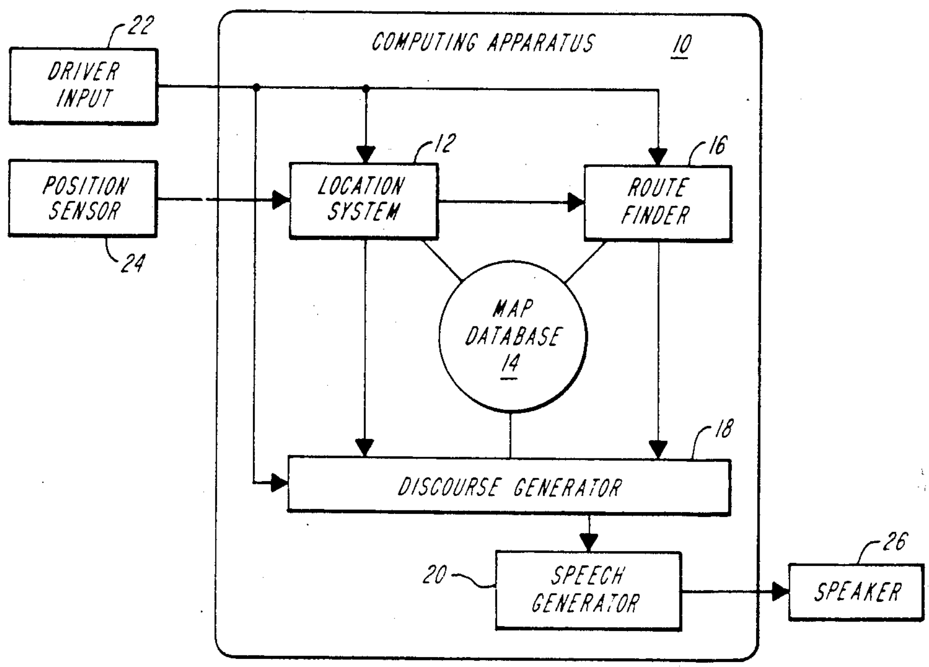
COMPUTING APPARATUS
10
22
DRIVER INPUT
POSITION SENSOR
24
12
LOCATION SYSTEM
16
ROUTE FINDER
MAP DATABASE 14
18
DISCOURSE GENERATOR
20
SPEECH GENERATOR
26
SPEAKER

FIG. 1

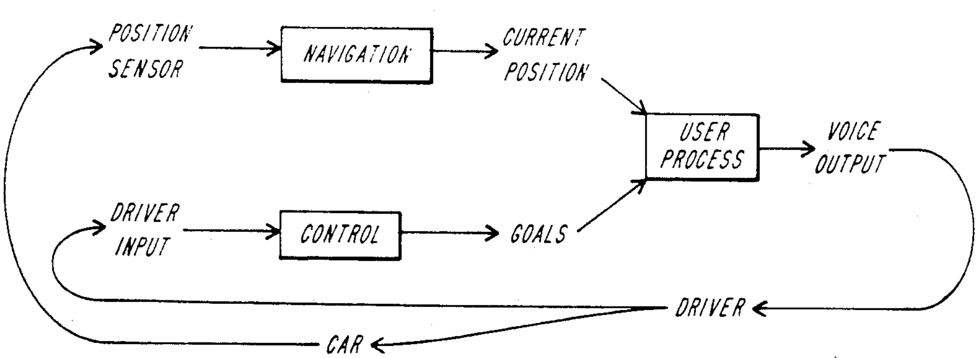
POSITION SENSOR
NAVIGATION
CURRENT POSITION
USER PROCESS
VOICE OUTPUT
DRIVER INPUT
CONTROL
GOALS
DRIVER
CAR

FIG. 2

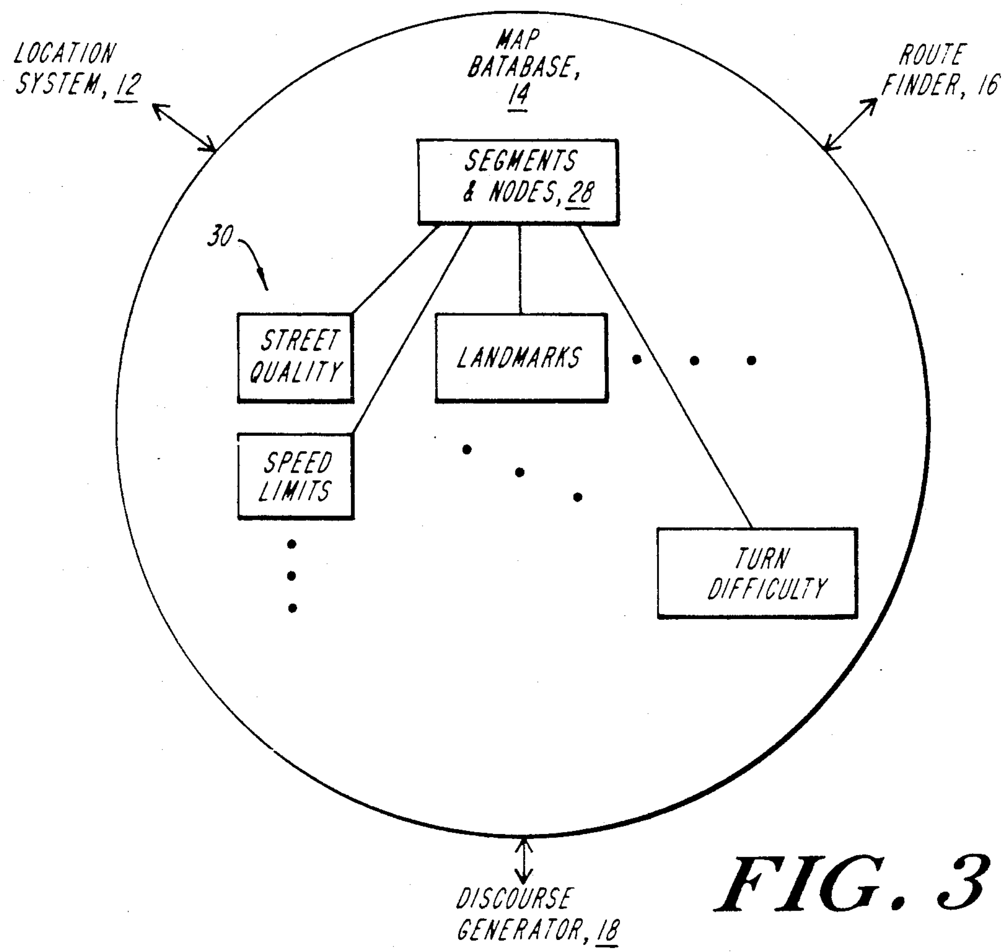
LOCATION SYSTEM, 12
MAP BATABASE, 14
ROUTE FINDER, 16
SEGMENTS & NODES, 28
30
STREET QUALITY
LANDMARKS
SPEED LIMITS
TURN DIFFICULTY
DISCOURSE GENERATOR, 18

FIG. 3

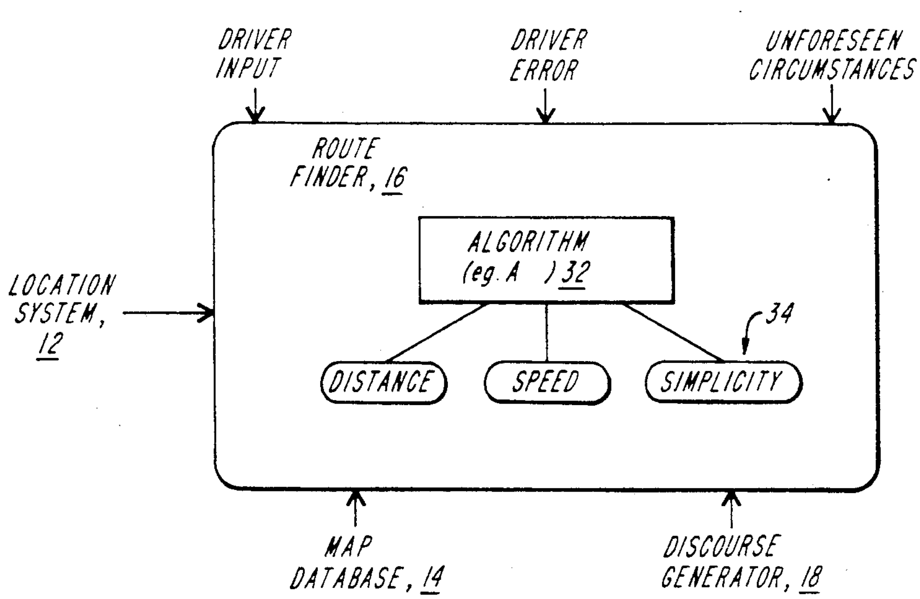
DRIVER INPUT
DRIVER ERROR
UNFORESEEN CIRCUMSTANCES
ROUTE FINDER, 16
ALGORITHM (eg. A) 32
LOCATION SYSTEM, 12
34
DISTANCE
SPEED
SIMPLICITY
MAP DATABASE, 14
DISCOURSE GENERATOR, 18

FIG. 4

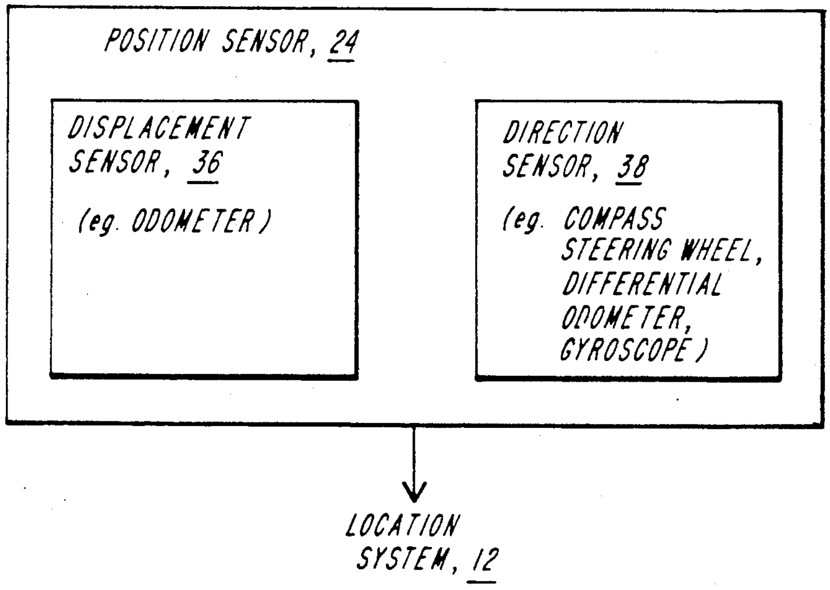
POSITION SENSOR, 24
DISPLACEMENT SENSOR, 36
(eg. ODOMETER)
DIRECTION SENSOR, 38
(eg. COMPASS STEERING WHEEL, DIFFERENTIAL ODOMETER, GYROSCOPE)
LOCATION SYSTEM, 12

FIG. 5

AUTOMOBILE NAVIGATION SYSTEM USING REAL TIME SPOKEN DRIVING INSTRUCTIONS

BACKGROUND OF THE INVENTION

This invention relates to computerized automobile navigation systems, particularly to a system which calculates a route to a destination, tracks automobile location, and provides spoken instructions to the driver in real time as they are needed.

Navigation systems can be classified into three categories:

Positioning systems tell you where you are.

Orienting systems show the direction of your destination.

Instructional systems tell you what to do to get to your destination.

A navigation system can provide one, two, or all of these services. Navigation systems can be further distinquished by how they provide the information:

Verbal systems speak.

Textual systems provide text.

Graphic systems provide pictures.

Finally, systems can be classified as either real time or static. The categories of this classification are not independent. There can be no static positioning system, since one cannot predict the future position of an automobile.

There are several problems with static navigation systems. First, they do not help the driver follow the route. The driver must determine when to apply each instruction. A second problem is that since the instructions must be specified in advance, there is little to be done if the driver does not follow the instructions, which might happen from error, or because the instructions are wrong, or simply ill-advised (as when confronting a traffic jam).

Previous automobile navigation systems have used text or graphics to give navigation information. However, there are several disadvantages to presenting information visually. First, the driver must look at a display while driving, which makes driving less safe. For providing driving directions, visual displays are most easily used when they are least needed. Second, with respect to graphic displays, many people have difficulty using maps, making this mode of providing information undesirable. However, if speech is used, the driver's eyes are left free for driving. In addition, speech uses words, and can therefore refer to past and future actions and objects not yet seen. This is hard to do with symbolic displays or maps.

There is clearly a need for an instructional, verbal, real time automobile navigation system which can guide a driver to a destination much as a passanger familiar with the route would. The present invention meets that need.

SUMMARY OF THE INVENTION

The present invention, called the "Back Seat Driver", is a computer navigation system which gives spoken instructions to the driver of an automobile to guide the driver to a desired destination. Computing apparatus, installed either in the automobile or accessed through a cellular car phone, contains a map database and a route finding algorithm. A vehicle location system uses data from a position sensor installed in the automobile to track the location of the automobile. Discourse generating programs compose driving instructions and other messages which are communicated to the driver using voice generating apparatus as the driver proceeds along the route.

The important differences between The Back Seat Driver and other such systems are that the Back Seat Driver finds routes for the driver, instead of simply displaying position on a map, tells the driver how to follow the route, step by step, instead of just showing the route, and speaks its instructions, instead of displaying them. Each of these design goals has required new features in the programs or in the street map database.

The street map database of the Back Seat Driver distinguishes between physical connectivity (how pieces of pavement connect) and legal connectivity (whether one can legally drive onto a physically connected piece of pavement). Legal connectivity is essential for route finding, and physical connectivity for describing the route.

To find the fastest routes, the map database of the Back Seat Driver includes features that affect speed of travel, including street quality, speed limit, traffic lights and stop signs. To generate directions, the map includes landmarks such as traffic lights and buildings, and additional descriptive information about the street segments, including street type, number of lanes, turn restrictions, street quality, and speed limit. The map also preferably includes other features, such as time-dependent legal connectivity, and expected rate of travel along streets and across intersections. Positions are preferably stored in the map database in three dimensions, not two, with sufficient accuracy that the headings of the streets can be accurately determined from the map segments.

Driving instructions generated by the Back Seat Driver are modeled after those given by people. The two issues for spoken directions are what to say (content) and when to say it (timing). The content of the instructions tells the driver what to do and where to do it. The Back Seat Driver has a large taxonomy of intersection types, and chooses verbs to indicate the kind of intersection and the way of moving through it. The instructions refer to landmarks and timing to tell the driver when to act.

Timing is critical because speech is transient. The Back Seat Driver gives instructions just in time for the driver to take the required action, and thus the driver need not remember the instruction or exert effort looking for the place to act. The Back Seat Driver also gives instructions in advance, if time allows, and the driver may request additional instructions at any time. If the driver makes a mistake, the Back Seat Driver describes the mistake, without casting blame, then finds a new route from the current location.

Giving instructions for following a route requires breaking the route down into a sequence of driving acts, and knowing when an act is obvious to the driver and when it needs to be mentioned. This further requires knowledge about the individual driver, for what is obvious to one may no be so to another. The Back Seat Driver preferably stores knowledge of its users, and uses this knowledge to customize its instructions to the preferences of the users.

Speech, especially synthetic speech, as an output media imposes constraints on the interface. The transient nature of speech requires that utterances be repeatable on demand. The Back Seat Driver has the ability to construct a new utterance with the same intent, but not necessarily the same words, as a previous message.

Synthetic speech being sometimes hard to understand. the Back Seat Driver chooses its words to provide redundancy in its utteranaces.

An actual working prototype of the Back Seat Driver has been implemented. It has successfully guided drivers unfamiliar with Cambridge. Mass. to their destinations. It is easy to foresee a practical implementation in the future.

BRIEF DESCRIPTION OF THE DRAWING

FIG. **1** illustrates schematically the basic functional components of the Back Seat Driver in its preferred embodiment.

FIG. **2** illustrates the system processes of the preferred embodiment of the Back Seat Driver.

FIG. **3** is a schematic illustration of the map database.

FIG. **4** is a schematic illustration of the route finder.

FIG. **5** is a schematic illustration of the position sensor.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The automobile navigation system according to the present invention is illustrated schematically in FIG. **1**. The heart of the system is a computing apparatus **10** comprising a vehicle location system **12**, a map database **14**, a route finder **16**, a discourse generator **18**, and a speech generator **20**. Driver input means **22** allows the driver to input to the computing apparatus **10** information such as a desired destination. A position sensor **24** measures automobile movement (magnitude and direction) and sends data to the location system **12** which tracks the position of the automobile on the map. The route finder **16** calculates a route to the destination. Based on the current position of the automobile and the route, the discourse generator **18** composes driving instructions and other messages according to a discourse model in real time as they are needed. The instructions and messages are sent to the speech generator **20** which conveys them to the driver by means of a speaker system **26**. The speaker system may be that of the car's radio.

In FIG. **1**, the computing apparatus is illustrated as a single entity. However, in other embodiments, the components may not all be implemented in the same piece of apparatus. For example, in one working prototype of the Back Seat Driver, the main computing apparatus is a Symbolics Lisp machine, but the location system is implemented separately by an NEC location system that tracks the position of the automobile using its own map database, and the speech generator is implemented separately by a Dectalk speech synthesizer. In another working prototype, the main computing apparatus is a Sun Sparc workstation. The map database for the Back Seat Driver can be provided on a CD-ROM, a floppy disk, or stored in solid-state memory, for example.

The components of the system and the system processes which coordinate their performance, particularly as embodied in the working prototypes, are discussed in the sections which follow. Aspects of the invention are also described in the following sources, which are hereby incorporated by reference:

1. "Synthetic speech for real time direction-giving," by C. M. Schmandt and J. R. Davis, *Digest of Technical Papers, International Conference on Consumer Electronics*, Rosemont, Ill., Jun. 6–9, 1989.
2. "Synthetic speech for real time direction-giving," by C. M. Schmandt and J. R. Davis, *IEEE Transactions on Consumer Electronics*, 35(3): 649–653, August 1989.
3. "The Back Seat Driver: Real time spoken driving instructions," by J. R. Davis and C. M. Schmandt, *Proceedings of the IEEE Vehicle Navigation and Information Systems Conference*, Toronto, Canada, September 1989.
4. "Back Seat Driver: Voice assisted automobile navigation," by J. R. Davis, Ph.D. thesis, Massachusetts Institute of Technology, September 1989.

MAP DATABASE

The map database for the Back Seat Driver in the working prototypes originated as a DIME (Dual Indepedent Map Encoding) file, a map format invented by the U.S. Census Bureau for the 1980 census. Implementing the Back Seat Driver required extending the DIME map format in a number of ways to make it useful for route finding and route describing.

The basic unit of the DIME file is the segment. A segment is a portion of a street (or other linear feature such as a railroad, property line, or shoreline) chosen to be small enough that it is a straight line and has no intersection with any other segment except at its endpoints.

The two endpoints of a segment are designated FROM and TO. If the segment is a street segment (as opposed to, say, a railroad) and has addresses on it, then the FROM endpoint is the one with the lowest address. Otherwise, the endpoint labels are chosen arbitrarily. A segment has two sides, left and right. The sides are chosen with respect to travel from the FROM endpoint to the TO endpoint. A navigator using a DIME file can find the location of an address along the segment by interpolating the addresses between the low and high addresses for the two endpoints. The DIME file is suited to determining the approximate position of a building from its street address.

Attributes of a DIME file segment include: its name (40 characters), its type (a one to four character abbreviation such as "ST"), the ZIP code for each side, and the addresses for each endpoint and each side. At each endpoint of a segment is a pointer to a node. A node represents the coordinates of that endpoint and the set of other segments which are physically connected at that endpoint. Segments share nodes. If any two segments have an endpoint at the same coordinate, they will both use the same node for that endpoint.

A vehicle navigation system using a DIME file can represent the position of a vehicle on the map by a structure called a position. A position has three parts: a segment, an orientation, and a distance. The segment is one of the segments from the map database, the orientation specifies the direction the vehicle is travelling (towards the TO or FROM endpoint), and the distance is the distance from the FROM endpoint of the segment, no matter which way the vehicle is oriented. When travelling towards the TO endpoint of the segment, distance increases, when travelling towards the FROM endpoint, it decreases.

The DIME file is not adequate for routing finding and is only marginal for generating route descriptions. The most important problem with the DIME format is that it indicates only if two segments are physically connected (that is, if they touch), but not whether they are legally connected (i.e. whether it is legal to travel from one to the other). Legal connectivity is crucial for route finding. However, legal connectivity does not

replace physical connectivity; route description requires information about physical connections as well. Physical connectivity also affects route finding directly when seeking the simplest route, since ease of description is determined in part by physical connectivity.

The most significant extension of the DIME file format required for its use in a vehicle navigation system is the explicit representation of legal connectivity. This can be accomplished by adding a legal connection list at each endpoint of a segment to indicate all segments which are legally accessible from that endpoint. This allows the route finder to consider only legal paths. To the inventor's knowledge, this has not been included in any other navigation system.

Another problem with the DIME file is that it is a planar graph. This means that no two segments can cross except at an intersection, so there is no way to correctly represent an overpass, for example. The DIME format represents an overpass by breaking both streets at the point where they cross, and creating a fictitious intersection even though the segments do not touch in reality. These false intersections are particularly troublesome since DIME does not represent legal connectivity, so it appears possbile and legal for a car to jump straight up and turn onto the overpass.

Points in the map database for a vehicle navigation system are therefore preferably three-dimensional. Route descriptions then provide better knowledge of the underlying topography. Stopping distance is affected by slope, so instructions must be given sooner when traveling down a hill. Slope affects safety. The route finder should avoid steep slopes in snowy weather. Finally, distance between points will be more accurate when change in altitude is considered. Roads designed for high speed may be more level than the underlying topography. They may be elevated or they may be depressed. A road which is not at grade will not have the slope of the land beneath it.

Coordinates in the DIME file are stored in ten thousandths of a degree. This means that the position of an endpoint in the map differs form the true position by as much as 6.5 meters in latitude and 5 meters in longitude at the latitude of Boston. This inherent position error causes problems because it introduces error in length and in heading. Uncertainty in heading causes uncertainty in the angle between two segments. A straight street can appear to wobble if it is made of many short segments. Segment "wobble" causes problems for a route finder, makes it hard to generate correct descriptions, and interferes with position determination.

DIME file segment "wobble" can be corrected for by assuming that the angle between two streets is the smallest possible value. However, this sometimes overestimates the speed an intersection can be travelled through. Uncertainty in the angle of segments at an intersection also makes it difficult to describe the intersection correctly and interferes with navigation because it makes it difficult to compare compass headings with the heading of a street.

A richer taxonomy of street types than that provided by DIME is preferable for a vehicle navigation system. Important categories of streets are: ordinary street, rotary, access ramp, underpass, tunnel, and bridge. Preferably, non-streets such as railroad, water, alley and walkway are also included.

The DIME file records a small amount of information about each segment. For a vehicle navigation system, additional attributes are preferably added to make better descriptions. Important additional attributes are street quality, divided roads, signs, traffic lights, stop signs, buildings, other landmarks, lane information, and speed limit.

The street quality can be, for example, a number from 1 ("super") to 4 ("bad") which combines the ease of locating and following the street and the expected rate of travel along it. The street quality attribute should be used by both the route finder and the route describer.

The identification of divided roads is necessary to avoid U Turns where they are not possible, although it is preferable to make U Turns only if there is no other alternative. In addition, the route finder should recognize that a divided road is safer than an undivided road.

Sign and exit numbers are preferably stored in the map database as connection cues, which are text strings that give cues for moving from one segment to another. Every cue has a type which tells the kind of cue, e.g. sign or exit-number. There may be more than one connection cue for a given pair of segments, but there should never be more than one of a type.

The most useful landmarks are traffic lights. Traffic lights are preferably stored independently for each endpoint of each segment, since the presence of a light at one segment of an intersection does not imply that all other segments at the intersection have a light.

Two types of buildings which are especially useful as landmarks are toll booths and gas stations. Toll booths can be stored as connection cues. Gas stations can be stored in the services database described below. However, a preferred approach is to index gas stations (and other buildings) by street.

Roads often have more than one lane. Selecting the proper lane can make travel faster, and it may even be mandatory, since certain turns may only be possible from some lanes. The map database therefore preferably contains the number of lanes for both directions on a segment, and whether one or more lanes is reserved for turn restrictions.

The map database also preferably includes time dependent legal connectivity. Sometimes a given turn will be prohibited at certain hours of the day, typically rush hour. Additionally, lanes sometimes switch direction during the day to accomodate rush hour traffic, and some lanes are reserved for carpools during rush hour.

The expected rate of travel is not necessarily a function of street quality. Although there is a correlation, travel rate is preferably a separate segment attribute. One reason is that travel rate, unlike quality, changes during the day. A model of traffic flow like that of an experienced driver (i.e. it should know what "rush hour" means) is preferably implemented in the map database.

Some turns, though legal, are difficult to make. The route finder preferably avoids these turns if possible. To an extent, the difficulty of a turn is implicit in the quality of the participating street segments, but an explicit model in the map database is preferred.

Some lanes or streets are restricted to certain kinds of traffic (car pools, no commerical vehicles). Also important are height restrictions, since some underpasses are so low that tall vehicles will not fit under them. This information is preferably included in the map database.

At some lights it is permitted to make a right turn at a red light after a full stop. Right turns here will be no slower than rights turns at a stop sign, so the route finder should prefer such intersections to those that do not permit it. Also, traffic lights have differing cycle

lengths. The map database preferably includes this information.

Local knowledge is also preferably included in the map database. These are facts about how people and institutions act on or near the road; e.g. that a speed trap is here, or that this road is one of the first ones plowed after a snow storm.

The Back Seat Driver should allow the driver to select famous destinations by name in addition to address by including this information in a database, and this database should be integrated with the services database, discussed below. The Back Seat Driver should also support names of buildings and office plazas made up by developers without reference to the street names.

Service locations are preferably stored in a services database. This database lists services such as gas stations, automatic teller machines and stores. For each service is recorded the name of the establishment, the address, phone number, and hours of operation. This allows the Back Seat Driver to select the closest provider of a service known to be open. The database can also be used as a source of landmarks when giving directions.

The map database preferably contains information on the division of the city into neighborhoods. This is useful for selecting an address. The postal ZIP code is not good for classifying neighborhoods.

Pronunciation information is preferably stored in a database for those place names which are easily mispronounced by the speech synthesizer. It would also be desirable to record which of those names have unusual spellings. This would allow the system to warn the driver to be alert for signs that might otherwise surprise her. Note that the driver only hears the name of a street, and has to guess how it is spelled from the sound she hears.

Abbreviations are preferably included to allow the user to enter certain street names in abbreviated form. A second use for abbreviations is to supply alternate spellings for streets, for example, to allow the driver to spell "Mt Auburn" as "Mount Auburn".

An almanac is preferably included to list the time of sunrise and sunset for the city. Arrangements can be made to either purchase this database or locate a program which an calculate it, for arbitrary position and date.

A problem for a practical Back Seat Driver is how to keep the map database accurate, since the streets network is constantly changing. Over time, new street are constructed, old streets are renamed or closed. These kinds of changes are predictable, slow, and long lasting. Other changes are unpredictable, quick, and transient. A road may be closed for repairs for the day, blocked by a fallen tree, or full of snow. Such changes are usually short lived. Thus, the Back Seat Driver needs the ability to change legal connectivity dynamically. In addition, the route finder should preferably have the ability to avoid congested roads caused by rush hour or accidents, for example. The map database is therefore preferably continuously updated by some form of radio broadcast by an agency that monitors construction and real time traffic conditions.

The Census Bureau, in cooperation with the United States Geological Survey, has designed a new map format known as TIGER (Topologically Integrated Geographic Encoding and Referencing) which has several improvements over the DIME format, but which is still a planar graph representing only physical connectivity. The map database for a Back Seat Driver could be also be originated from a TIGER file as long as the extensions discussed above were implemented.

The map database is shown schematically in FIG. 3. In the preferred embodiment, the map database **14** includes, as its basis, a file **28** of segments and nodes. File **28** may be an original file or may be adapted from a DIME file or a TIGER file by adding the above-described extensions. In addition, the map database **14** may include optional features **30**, as described above.

ROUTE FINDER

Finding a route between two points in a street network is an example of searching a general graph. The task is to find a sequence of segments that lead from the origin to the destination. There are usually a great many distinct ways of getting from one place in the city to another, some better than others. Graph search algorithms differ in the quality of the solution they find and the time they require. The Back Seat Driver requires an algorithm that finds a good route in a short time.

The route finder of the working prototypes of the Back Seat Driver is based on an A* search algorithm. The A* algorithm is a form of best-first search, which itself is a form of breadth-first search. These searching techniques are well-known and are described in detail in Davis, 1989, cited above.

In a breadth-first search, a tree of all possible decisions is divided into levels, where the first level actions are those leading from the root, the second level actions are those that come from situations after first level actions, and so on. All actions at a given level are considered before any at the next higher level. While the breadth-first search is operating, it maintains a list of all possible partial routes and systematically examines every possible path from the end of every partial route to compile a new list of partial routes. This search procedure finds the path with the fewest segments. However, this is not necessarily the best path. To be sure of finding the best path, the search cannot stop when the first path is found, but must continue, expanding each path, until all paths are complete. This is not at all desirable, since there could be (and in fact will be) many paths.

The best-first algorithm solves this problem by keeping track of the (partial) cost of each path, and examining the one with the smallest cost so far. This requires a function that can compare two routes and produce a numeric rating. Such a function is called a metric. To further reduce the cost of searching, before adding a segment to a path, the best-first search checks to see whether it is a member of any other path. If it is, it is not added, for presence on the other path means that the other path was a less expensive way of reaching the same segment.

Best-first search finds the best solution and requires less time than exhaustive breadth-first search, but it still must consider partial solutions with an initial low cost which prove expensive when complete. The A* algorithm avoids wasting time on such falsely promising solutions by including an estimate for the completed cost when selecting the next partial solution to work on. The cost estimate function is $f^*(r)=g^*(r)+h^*(r)$, where r is a route, $g^*(r)$ is the known cost of the partial route, and $h^*(r)$ is the estimate of the cost to go from the endpoint of the route to the goal. The h^* function must have the property of being always non-negative and

never over-estimating the remaining cost. An h* meeting these two conditions is said to be admissible. It should be obvious that if h* is chosen to be always zero, then A* search is just best-first search. In applying A* to finding routes on a map, h* is just the cartesian distance between the endpoint of the partial route and the destination point. It is certain that no route will be shorter than the straight line, so this estimate is never an over estimate. A* search is more efficient than best-first.

The A* algorithm finds the optimum route, but the Back Seat Driver might be better served with an algorithm that finds a reasonable route in less time. This is especially true when the vehicle is in motion. The longer the route finder takes, the greater the distance that must be reserved for route finding. As this distance becomes larger, it becomes harder to predict the future position of the car. This can be done by choosing an h* which multiplies the estimated distance remaining by a constant D. Setting D greater than one makes h* no longer admissible, since the estimate might exceed the actual cost by a factor of D. The resulting routes are no longer optimal, but are still pretty good. The effect is to make the algorithm reluctant to consider routes which initially lead away from the goal.

The route finder preferably uses a value of 2 for D. This yields the greatest increase in payoff. A possible improvement is to run the route finder twice, first with a high value of D to find an initial route in order to begin the trip, and then with a low D to search for a better route, using spare time while driving.

Preferably, three different metrics are used. The distance metric finds the shortest route, the speed metric finds the fastest route, and the ease metric finds the easiest route. The metric for distance is just the sum of the lengths of the component segments. The other two metrics are more complicated than the distance metric, because they must consider intersections as well as segments. In general there is a cost to travel along a segment and a cost to get from one segment to another. All costs are expressed as an "equivalent distance" which is the extra distance one would travel to avoid the cost.

The metric for speed estimates the cost for traveling along a segment by multiplying its length by a constant which depends upon the quality of the street. In principle, one could calculate expected time by dividing length by the average speed on the segment were this quantity available in the database. Examples of appropriate constants are:

Quality	Factor
super	1
good	1.2
average	1.5
bad	2.0

All multiplicative constants must be greater than or equal to one to ensure that the cost of a route is never less than the straight line distance between two points. This condition is essential for the correct operation of the A* search algorithm, since the estimation function (g*) must always return an under-estimate.

The time to cross an intersection is preferably modeled by a mileage penalty which depends upon the nature of the intersection. Examples of appropriate penalties are:

Factor	Cost	Reason
turn	1/8 mile	Must slow down to turn
left turn	1/4 mile	May have to wait for turn across traffic flow
traffic light	1/8 mile	Might be red

If the segment is one-way, the penalties should be cut in half, since there will be no opposing traffic flow. The turning penalties should be computed based only on the angle between two segments, not on the segment type or quality.

The metric for ease seeks to minimize the driver's effort in following the route. Again, driver's effort is the sum of the effort to travel along a segment and the effort to get from one segment to another. Travel along a segment depends upon its quality. Turns of every sort should be penalized equally, since they all require decisions. The intention of this metric is to find routes which require the least amount of speaking by the Back Seat Driver, leaving the driver free to concentrate on other matters.

If the driver leaves the route, the Back Seat Driver must immediately inform the driver and begin to plan a new route. Route planning after a mistake is no different from any other time, except that the vehicle is more likely to be moving. In the working prototypes, when the car is moving, the Back Seat Driver first estimates the distance the car will travel during the route finding process by multiplying the current velocity by the estimated time to find the route. Then it finds the position the driver will reach after traveling this distance, assuming that the driver will not make any turns without being told to do so. It then finds a route from this extrapolated position to the goal. Finally, it finds a route from the car's actual position to the estimated starting position. This second route is so short that the car is unlikely to move far during the time it is computed.

The route finder of the working prototypes estimates the time to find the route between two points by multiplying the distance between them by a constant. This constant was initially determined by running the route finder for 20 randomly selected pairs of origins and destinations. As the Back Seat Driver runs, it accumulates additional values for the constant.

A problem is how to reliably detect when the driver has left the route. With the extended DIME format of the working prototypes, if the driver turns into a gas station, for example, the system will believe, falsely, that the driver has turned onto some street, because the street map includes only streets, and not other paved areas such as parking lots and filling stations. From this false belief, the system will conclude that the driver has made a mistake. However, this problem can be solved by increasing the detail of the map.

Sometimes the driver will choose to not follow a route for good reasons that the Back Seat Driver is unaware of, perhaps because the road is blocked or because of a traffic jam. For the first case, the driver should be provided an "I Can't Do It" button or other means to inform the Back Seat Driver that the road is (temporarily) blocked. Once informed, the Back Seat Driver must automatically find a new route. For the second case, the driver's only recourse is to cancel the current trip (by pushing another button, for example), and, once out of the situation, re-request a route to the original destination. It is essential, though, that the

driver either notify the Back Seat Driver of the impossibility of the requested action or cancel the trip, because otherwise the Back Seat Driver will treat the deviation from the route as a mistake, and continue to attempt to find a new route, which may very well lead back through the street the driver is trying to avoid.

The route finder is shown schematically in FIG. **4**. In the preferred embodiment, the route finder **16** includes, as its basis, an algorithm **32**. Algorithm **32** may be, for example, an original algorithm based on a best-first search algorithm the A* algorithm, or a modified A* algorithm. In preferred embodiments, the route finder is adapted to find the best route according to any one of three cost metrics **34**: distance, speed, simplicity. The route finder calculates a new route in the event of driver error or unforeseen circumstances, as indicated.

LOCATION SYSTEM AND POSITION SENSOR

The Back Seat Driver must know the position of the vehicle. This can be achieved using available technology adapted for the requirements of the Back Seat Driver. At a minimum, the location system for a vehicle navigation system must determine the vehicle position to the nearest block. If it is to tell the driver when to turn, it must be able to distinguish between the closest of two adjacent turns.

Consideration of the Boston street map shows that it has many streets which are both short and a possible choice point. Based on a study of the percentage of segments which are shorter than a given length, an accuracy of 10 meters is desirable. This is a higher accuracy than has been specified in prior art approaches (see Davis, 1989, cited above). The Back Seat Driver's use of speech imposes strict requirements on position because of limitations on time. Unlike a display, speech is transient. An action described too soon may be forgotten. The Back Seat Driver is intended to speak at the latest time that still permits the driver to act. Allowing two seconds for speech, a car at 30 mph covers 27 meters. This consideration suggests a minimum accuracy of 15 meters.

Location systems can be divided into two categories:

Position finding systems determine position directly by detecting an external signal.

Position keeping (dead reckoning) systems estimate the current position from knowledge of an earlier position and the change in position since that position.

All existing position finding systems use radio signals. The broadcast stations may be located on street corners, seacoasts, or in orbit around the earth. Systems differ in their range, accuracy, and cost. A survey of those systems which might plausibly be used for automobile navigation is included in Davis, 1989, cited above.

Position keeping (dead reckoning) systems obtain position indirectly, by keeping track of the displacement from an originally known position. One can measure displacement directly, or measure velocity or acceleration and integrate over time to obtain displacement.

The forward motion of a car is measured by the odometer. On late model cars, the odometer cable has been standardized. It revolves once every 1.56 meters. This is a reliable measure of forward progress, as long as the wheels do not slip. Measuring direction, though, is more difficult. Among the possibilities are:

magnetic compass A magnetic compass has the advantages of small size and ease of use, but is unreliable because of variation between magnetic and true north and deviation due to the ferrous material of the car and magnetic flux arising from electric currents within the car.

steering wheel The steering wheel could be instrumented to measure the amount of turning.

differential odometer When a car turns, the two rear wheels travel different distances, and thus rotate at different rates. Measuring the difference in rotation provides an indication of amount of turning. This differential rate of rotation is just what is measured by anti-skid brakes, so no additional instrumentation is required to obtain this measure for an automobile suitably equiped.

gyroscope Gyroscopes measure angular acceleration. The familiar rotation gyroscope and esoteric laser ring gyroscope are not suitable for automotive use because they are too expensive. Lower cost alternatives are the rate gyro and the gas jet gyro. The rate gyro measures angular acceleration in a vibrating piezo-electric substance. The gas gyro measures turn (or yaw) rate. In this design, a jet of gas travels down the center of a sealed tube. Anemometers are placed on either side of stream. When the car turns, the stream is deflected and the velocity is measured. The velocity of the gas at the anemometer is proportional to the turn rate. Such devices can measure turn rates of up to 100 degrees per second, with a noise of about one half degree/second.

The position sensor is shown schematically in FIG. **5**. As indicated, it includes a displacement sensor **36** and a direction sensor **38**.

A position keeping system with no error could be calibrated when installed, and then maintain its own position indefinitely. Unfortunately, errors arise in measuring both distance and heading. Sources for error include difference in tire pressure, composition and wear, slipping, cross steering from winds, change in tire contact path in turns, magnetic anomalies, and gyro noise. The NEC dead reckoning system, employed in the prototypes of the Back Seat Driver, accumulates about one meter of error for every ten meters traveled. The error is even worse when traveling near railroads because the NEC system uses a magnetic compass.

Some dead reckoning systems recalibrate themselves to eliminate systematic errors. Such recalibration is possible when the vehicle is at a known position or when stopped. One way to correct dead reckoning errors is to use knowledge of the road network as a constraint on position, in what is known as map matching. Map matching requires that the position keeping system have a map of the locale where the vehicle is being driven, and is based on the assumption that the vehicle is always on a street present in the map. If the estimated position falls to one side of the road, the estimate can be corrected. When the vehicle makes a turn, the system assumes the vehicle is at the closest intersection, and thus the absolute position can be estimated. Every dead reckoning system uses some form of map matching. Map matching reduces the stringency of position keeping, but accuracy remains a concern, since the system must maintain its position when the driver drives off the map, e.g. into a driveway or a parking lot.

In the working prototypes, a unit built by NEC Home Electronics, Ltd. is employed. It is a dead-reckoning position keeping system which uses speed and direction sensors. To compensate for error, it uses map matching on a map database stored on CD-ROM. The unit is described in "CD-ROM Assisted Navigation

Systems" by O. Ono, H. Ooe, and M. Sakamoto, in *Digest of Technical Papers, IEEE International Conference on Consumer Electronics*, Rosemont, Ill., Jun. 8–10, 1988.

As implemented in the working prototypes, the map database used by the location system is completely distinct from the map database used by the route finder and discourse generator. This is unfortunate since the maps will not always agree unless they are kept equally up-to-date. However, in other embodiments within the scope of the invention, the location system uses the computing resources and map database of the main computing apparatus illustrated in FIG. 1. Positioning systems for the Back Seat Driver preferably combine position keeping and position finding, since neither alone will work all the time. A position keeping system needs periodic corrections, but a position finding system that depends on radio reception will not work in tunnels or bridges. Hybrid systems which could be used by the Back Seat Driver are referenced and discussed in Davis, 1989, cited above.

DISCOURSE GENERATOR

The Back Seat Driver attempts to provide instructions to the driver as a passenger in the car familiar with the route would. The content and timing of the instructions and other messages described below are based on a study of natural driving instruction described in detail in Davis, 1989, cited above.

To the Back Seat Driver, a route is a sequence of street segments leading from the origin to the destination. Each connection from one segment to another is considered an intersection, even if there is only one next segment at the intersection. At any moment, the car will be on one of the segments of the route, approaching an intersection. The task of the Back Seat Driver is to say whatever is necessary to get the driver to go from the current segment, across the intersection, to the next segment of the route. Most often, nothing need be said. But at other times, the Back Seat Driver will need to give an instruction.

Instructions must use terms familiar to the driver. An example is what to say at a fork in the road. Considering only topology, there is no difference between a fork and a turn, but it would be confusing to call a fork a turn.

The two key issues in describing a route are deciding what to say and deciding when to say it. There is a tradeoff between these two factors. At one extreme are directions given completely in advance, with no control over when the driver reads them. A direction of this kind might be: "Go half a mile, then take a left onto Mulberry Street". A driver following such an instruction must use the odometer to estimate distance or look for a street sign. The instruction itself does not say when to act. The other extreme are instructions which rely totally on timing for success. Such an instruction might be: "Turn left now".

An intersection type is called an act because the important thing about an intersection is what action the driver takes to get across it. The Back Seat Driver is preferably implemented with an object-oriented programming methodology, so for each act there is an expert (an object) capable of recognizing and describing the act. The Back Seat Driver generates speech by consulting these experts. At any moment, there will be exactly one expert in charge of telling the driver what to do. To select this expert, the Back Seat Driver asks each expert in turn to decide whether it applies to the intersection. The experts are consulted in a fixed order, the most specific ones first. The first expert to claim responsibility is selected. This expert then has the responsibility of deciding what (if anything) to say.

Each act has a recognition predicate which is used to determine if a given intersection should be classified as that act. A predicate can consider topology, geometry, the types of street involved, or any other factor. The predicate also decides whether the move is obvious, that is, the driver can be trusted to do it without being explicitly told to do so. Actions that are obvious are not described. If the next action is obvious, the Back Seat Driver looks ahead along the route until it finds one which is not obvious. There will always be at least one, because stopping at the end is never obvious.

The acts in the working prototypes include CONTINUE, FORCED-TURN, U-TURN, ENTER, EXIT, ONTO-ROTARY, EXIT-ROTARY, STAY-ON-ROTARY, FORK, TURN and STOP.

A CONTINUE is recognized when the driver is to stay on the "same" road. Almost always, a continue is obvious and nothing should be said. The continuation of a street depends on the type of street: from a rotary, it is the next rotary segment; from an access ramp, if there is exactly one next segment, that is the continuation, otherwise there is no obvious next segment; otherwise, it is the one segment that requires no more than 30 degrees of angle change (if there is exactly one, and if it is not a rotary) or the one segment with the same name (if there is exactly one). The reason for comparing names is not because the driver is aware of the name, but because the designer who named the street was. The assumption is that if two segments have the same name, they are the same street, and that is why they have the same name. This "sameness" is presumably reflected in details not captured by the map, for example continuity of painted centerline. There are many places in the area where the obvious "straight" continuation of a segment is at an angle as great as 45 degrees, but it would not be right to call this a turn.

A FORCED-TURN is an intersection where there is only one next street segment where the road bends more than 10 degrees. Even though there is no decision to make at a forced turn, it is useful to mention because it strengthens the driver's sense that the Back Seat Driver really knows about the road conditions. A forced turn is not worth mentioning if both segments are part of a bridge, a tunnel, or an access ramp, or if the angle is less than 20 degrees.

The U-TURN action is recognized when the heading of the car is the opposite of what it should be. Recall that a route is a sequence of segments and endpoints. At all times the car will be on one of the segments in the sequence. If the car's orientation is not the same as the endpoint in the path, then the driver must turn around. Preferably, the route finder only calls for a U Turn if there is no other way.

To ENTER is to move onto a super street (or an access ramp that leads eventually to a super street) from an ordinary street, but not from a super street or an earlier access ramp. Similarly, to EXIT is to move from a super street onto a street with lesser quality that is either an access ramp or has a different name. Some super streets are not uniformly super and it would not be right to call the change in quality an exit.

To go ONTO-ROTARY, to STAY-ON-ROTARY, and to EXIT-ROTARY are acts which can be correctly

described only if the street map database includes an explicit marking of streets as rotaries.

At a FORK, there must be at least two alternatives, all within a narrow angle, and none of the branches must be the obvious next segment—that is, the branches must all be more or less equal. Either all the alternatives must be access ramps, or none of them must be. A branch can only be considered obvious if it is the only branch with the same level of quality, or if it is markedly straighter than the others, or if it is the only one with the same number of lanes, provided that all of these clues agree. If one branch is stronger than the others, the intersection is not a fork. It is either a continue or a turn.

The STOP action is recognized when the vehicle is on the destination segment. Finally, a TURN is an intersection not handled by one of the above cases. The greatest weakness of the above approach is that the recognition predicates are sensitive to small changes in the angles between segments. It is not likely that people use absolute numbers (e.g. 10 degrees) as cut-off values for their determination of how to describe an intersection. More likely, different classifications compete. Still more important, people making classifications use visual cues, not just facts from the map.

Each act has a description function to generate a description of the action. The description function takes inputs specifying the size of the description (brief or long), the tense (past, present or future), and the reference position. A short description is the minimum necessary for the act. It is typically an imperative (e.g. "Bear left."). A long description includes other facts about the action, an expression indicating the distance or time until the act is to be performed, and possibly information about the next act, if it is close. The reference position is a position (along the route) from which the action is to be described.

A brief description consists only of a verb phrase. The verb depends on the type of act and perhaps on the specifics of the act. Besides the verb itself, the verb phrase must say which way to go. In most cases, the word "left" or "right" is sufficient. Where it is not, the possibilities are to use a landmark or to describe the turn. A landmark can be either in the appropriate direction ("towards the underpass") or the other direction ("away from the river"). Specifying direction with a landmark has the advantage that some drivers confuse left and right sides, or mishear the words, so it is a redundant cue. Also, it increases the driver's confidence that the system really knows what the land looks like. A description of the turn can mention either quality or the relative angle of the desired road. The angle must be described qualitatively (more or less "sharp"). It would be more precise to use the angular distance (e.g. "turn right 83 degrees"), but drivers would not understand it. Preferably, the expert for each act follows a protocol which includes:

recognize?—is a proposed movement an example of this kind of driving act?

instruction-vp—generate a verb phrase describing this act

instruction-np—generate a noun phrase describing the act

position-to-doit—the position where the driver would begin carrying out the act

obvious?—would the driver do this act without being told?

sentences—generate all sentences needed to describe this act

congratulate?—should the driver be congratulated after carrying out this kind of act

The following sample is a Back Seat Driver description of the left turn from Fulkerson Street to Main Street in Kendall Square, Cambridge, Mass.:

> Get in the left lane because you're going to take a left at the next set of lights. It's a complicated intersection because there are two streets on the left. You want the sharper of the two. It's also the better of them. After the turn, get into the right lane.

This instruction begins with a piece of lane advice, an action to be taken immediately, then describes an action in the near future. The action is a turn, though that word is not used explicitly. It tells the direction of the turn (left) and specifies a landmark (the lights) that says where the turn is. In many cases, this would be enough, but here there are two streets on the left, so the instruction goes on to specify the desired road in two ways (by comparative position and relative quality). Finally, it concludes with some lane advice to be executed during (or just after) the act.

The above example is the most complicated text that the Back Seat Driver prototypes have produced. Length and detail are not virtues in giving directions. The Back Seat Driver produces a text this long only because it does not have better means to make the driver follow the route. If a shorter text would accomplish the same aim, it would be better.

Besides telling drivers what to do, the Back Seat Driver must also tell them when to do it. One way to do this is by speaking at the moment to act, but it is useful to also give instructions before the act, if time permits. This allows time for preparation, if required, permits the driver to hear the instruction twice, and also spares the driver the need to be constantly alert for a command which must be obeyed at once.

When an act is more than a few seconds in the future, The Back Seat Driver uses a long description, which includes one or more cues which either describe the place for the act, the features of the road between the current location and the place, or the distance or time until the act. This description should be so clear that the driver cannot only recognize the place when it comes, but can also be confident in advance that she will be able to recognize the place.

The Back Seat Driver preferably uses a landmark as a cue when it can. A numeric distance is the cue of last resort. However, some drivers prefer to also hear distances, especially if the distance exceeds a certain threshold. Therefore, a parameter is preferably included in the user-model, described below, for this minimum distance expressed as a number. If the distance is below this, a qualitative phrase is produced by the discourse generator, if above, a number is produced. The cutoff can be zero, in which case numbers are always used, or set to an infinite value, in which case they never are.

A cue is expressed either as a full sentence ("Drive to the end of the street, then . . . ") or a preposed preposition phrase ("At the next set of lights, . . . "). Research has shown that a cue should not be expressed by a preposition after the verb as in "Take a left at the lights." because some drivers start to take the left as soon as they hear the word "left". This may be because syn-

thetic speech does not provide enough intonational cues for the driver to reliably predict the length of the sentence, leading the driver to act on syntactic information alone, and thus taking the sentence to be complete as soon as the word "left" is heard.

The description of a road feature depends upon whether or not it is visible. If it is, it can be referred to with a definite article ("the rotary", "the overpass"). If not, an indefinite article is used. The program cannot tell whether an entity is actually visible, so it uses distance as an approximation. If the feature is closer than one tenth of a mile, it is considered to be visible.

A special case of cues is when the driver is at the place to act. When stopped a few meters from the intersection, it is wrong to say "Turn at the next lights" even if it is literally true. In the working prototypes, the Back Seat Driver thinks of itself as being at that intersection it if its less than thirty yards away, except that if there is a stop light at the intersection and the car is not moving, then the intersection distance if fifty yards, since cars might be backed up at such an intersection. When at an intersection, the Back Seat Driver should say "Take a left here" rather than "Take a left now" because drivers waiting for a traffic light will rightly resent being told to do something they have good reason not to do.

Traffic lights are very good landmarks because they are designed to be easily seen and drivers have an independent reason to watch for them, namely a desire to avoid accidents. When referring to a traffic light, if the car is at the intersection for the lights, the Back Seat Driver should use a proximal deictic ("this" or "these", as opposed to the distal "that" or "those") to show it means the lights that are here.

The Back Seat Driver preferably has a database of buildings as part of its directory of services. If it finds a building on the corner, it should include it as a potential landmark; e.g. "Look for Merit Gas on the left side".

Other landmarks are features of the road, such as underpasses, bridges, tunnels, bends in the road, and railroad crossings. Still another potential landmark is the road coming to an end. This is a landmark that is impossible to miss. However, research has shown that if the Back Seat Driver says "Drive all the way to the end, then . . . ," some drivers take "the end" to mean not "the farthest you can go along this road" but just "the next intersection".

A street name can be a landmark, but not a good one, unless the driver already knows the street. There are several reasons why street names should not be used. First, the driver may not hear the name correctly. Second, the driver may hear the name, but not know how to spell the name after hearing it, so she may not recognize the name in its printed form. This is especially a problem when the driver is from out of town. Finally, even if the driver knows the spelling, street signs are often missing, turned around, or invisible due to weather or darkness. Despite all the problems that come with using street names, many drivers ask for them. To accommodate them, a parameter in the user-model is preferably included to control the use of names. If set, names are supplied as part of the instruction. When names are included, they are preferably attached at the end of the instruction ("Take the second left. It's Elm Street.") rather than directly ("Take the second left onto Elm Street."), which weakens their salience somewhat, and makes them more of a confirmatory cue than an essential one.

Signs can be important landmarks. A problem with using signs as cues occurs, however, if the information in the sign is stored as unstructured text in the map database. It is important that the Back Seat Driver understand what the sign says, not simply utter the words. There are two reasons for this. First, the Back Seat Driver's internal representation for text is preferably based on syntactic structure, not text strings. Second, the objects mentioned in the signs (cities and roads) should be entered into the discourse model to become salient for future reference. The Back Seat Driver should parse sign text by separating it into tokens delimited by commas and the word "and", and then attempt to recognize objects on the map (street names, cities, neighborhoods) from these tokens. When recognition fails, the token cannot be entered into the discourse model. When parsing fails, the spoken output will have incorrect grammar.

The Back Seat Driver does not assume that the driver will recognize the place to act (e.g. by seeing a street sign) so the driver must be told when (or where) to act. The Back Seat Driver uses timing ("Take a left here") when the driver has reached the place to act. The working prototypes calculate the place to speak by finding a distance from the intersection which is $v * (t_{speak} + t_{reaction})$, where t_{speak} is the time to speak the utterance and $t_{reaction}$ is the driver's reaction time. The time to speak depends on the number of words in the utterance. (The Dectalk synthesizer used in the prototypes speaks 180 words per minute.) Reaction time can be estimated to be two seconds.

The Back Seat driver speaks autonomously, but preferably provides means to allow it to speak on demand. The driver at any time should be able to ask for instructions immediately by, for example, pushing buttons representing "What next?" and "What now?". In addition, while following a route, a driver should be able to ask to hear the total length of the route and the remaining distance. A driver should also be able to ask to hear the name of the street the car is on and the compass direction the car is headed.

In order to generate more fluent text, the Back Seat Driver preferably keeps track of what has been mentioned. Some instructions are obvious after having been given. If the system tells the driver to go straight through a set of lights, there is no reason to repeat the instruction when actually at the lights. This is in contrast with a turn, where the driver hears advance instructions to know what to do, and immediate instructions to know when to do it. This can be important, for if the driver hears "go straight through the lights" twice, she may try to go through two sets of lights. To implement this, each instruction should be able to determine whether it is obvious after having been given once. When it is time to speak the instruction, if the instruction has already been given, and it is obvious once spoken, then it should not be spoken again.

The Back Seat Driver preferably retains a history of the route. This allows it to generate cue phrases for the instructions. If the route calls for doing the same thing twice in a row, the system uses the work "another" to indicate this doubling. This is important for polite behavior. If a passenger were to give a driver instructions by just saying "Take a right. Take a right. Take a left. Take a right.", pronouncing each the same, the passenger would be judged to be rude. The passenger's speech is not acknowledging the driver's actions or history. There are two ways for the passenger to acknowledge

the driver's work: using cue words ("Take a right. Take another right. Now take a left."), or using intonation. However, some speech synthesizers, such as the Dectalk used in the prototypes, does not support flexible control of intonation, so cue words are the only possibilty.

The Back Seat Driver preferably is able to warn the driver about dangers which can be inferred from knowledge of the road network. These dangers include driving above the speed limit, driving the wrong way on a one-way street, driving too fast for an upcoming curve, driving on a one-way street that becomes two-way ahead, merging traffic, "blind" driveways ahead, speed traps, poorly repaired roads, potholes, and dangerous intersections. The Back Seat Driver preferably attempts to determine hazards by reasoning about road conditions rather than requiring them to be built in to the map database.

Lane advice includes telling the driver which lane to get into (or stay out of) when applicable. The system gives lane advice as part of the instruction when approaching an intersection where it matters. The instruction may also include advice about what lane to be in after the intersection, in preparation for the next act.

Speed advice includes warning the driver to slow down if she is travelling too fast to safely negotiate a turn. The limiting factor for angular acceleration is the driver, not the cornering ability of the car. Research has shown that the average driver will accept no more an 0.1 G radial acceleration. Radial acceleration is v^2/r where r is the turning radius of the turn. The Back Seat Driver knows the geometry of the road, so it can predict the maximum tolerable velocity for the turn. It need not tell the driver about this speed (the driver will choose a comfortable speed without being told), but it should estimate the distance required to decelerate, and tell the driver to slow down early enough to do this gently.

If the driver leaves the route, the Back Seat Driver immediately informs the driver and begins to plan a new route. Telling the driver what she did wrong prepares her for hearing new instructions, and perhaps helps her learn to better interpret the style of language that the Back Seat Driver uses.

To describe an error, the Back Seat Driver needs to look back to the last action that the driver failed to perform. It should utter a description of this action, saying e.g. "Oops, I meant for you to take a right," which does not blame the driver as in e.g. "You made a mistake. You should have taken a right." A driver might leave the route deliberately, or the error could be system's, not the drivers.

Errors will occur due to inaccuracies in the location system. The Back Seat Driver is preferably able to model the uncertainty of a position. For instance, when two roads diverge at a narrow angle, it will be unable to distinguish which was taken until some distance passes. It should probably assume that the driver made the correct choice rather than taking the risk of making a false accusation. If it reaches a place where the difference is crucial, yet unknown, it is probably better for it to confess its uncertainty, and say something like "I'm not quite sure where we are, but if you can take a right here, do it, and if not, keep going, and I'll figure things out better in a minute." Or it might ask the driver to pull over and stop (if the driver is at a place where that is safe) to allow for a better position estimate by averaging a few successive estimates.

Errors will also occur if the database is somewhat out of date. The Back Seat Driver can regain at least a little confidence by how it explains the mistake. Suppose that the Back Seat Driver intends the driver to turn onto "Apple" Street, and says "Take a right at the next light". Unbeknownst to it, a new traffic light has been installed at "Pear" Street, so the driver turns there. It is somewhat confusing if the Back Seat Driver says "I meant for you to go straight," because the driver may think that the program has not been consistent. A better message would be "I did not mean for you to turn onto Pear. I thought that the next set of lights was at Apple Street."

While the driver is following a route, the Back Seat Driver preferably adopts a persistent goal of keeping the user reassured about her progress and the system's reliability. If the Back Seat Driver were a human, this might be unnecessary, since the driver could see for herself whether the navigator was awake and attending to the road and driver. But the driver cannot see the Back Seat Driver and so needs some periodic evidence that the system is still there. One piece of evidence is the safety warnings the system gives. But if all is going well, there will not be any. Other kinds of evidence that things are going well should be provided. When the user completes an action, the Back Seat Driver can acknowledge the driver's correct action, saying something like "nice work" or "good". Also, insignificant remarks about the roads nearby, the weather and so on, can be provided. The driver then assumes that everything is going well, for otherwise the Back Seat Driver would not speak of trivial matters.

The Back Seat Driver should know about the knowledge and desires of its driver, and act differently because of this knowledge. This knowledge is preferably incorporated in a user-model.

For driver properties which do not change or change very slowly, such as colorblindness, or visual or aural acuity, it is acceptable for the Back Seat Driver to ask the user for such knowledge. However, for other driver properties, the Back Seat Driver preferably acquires a model of the user automatically, without asking or having to be told. For example, the Back Seat Driver could learn the driver's reaction time by measuring the time between its speech and the driver's operation of the controls.

The Back Seat Driver preferably learns the style of instruction giving appropriate for the driver. To learn the driver's preferences for route description requires either observation of the driver herself giving instructions or getting feedback from the driver about the instructions the system provides.

The driver can provide feedback about the suitability of the Back Seat Driver's instructions either explicitly or implicitly. One explicit indication of comprehension is how often the driver hits the "what now?" button. The system might collect long term statistics on the types of intersections where the user most often requests help, and begin to offer instructions without being asked. Just as the user can ask for more talking with the "what now" button, the Back Seat Driver should provide a "shut up" button (or other means to the same effect). The Back Seat Driver could also learn the effectiveness of its directions simply by watching the driver's performance—in particular, her errors. In this way, it can learn which cues are most effective.

Another opportunity for learning the driver's style is during the acquisition of speech recognition templates

(for user-dependent speech recognition for driver input means, described below). The new user should play the role of a "back seat driver" and give instructions, while in a car, for some route. The instructions must be given while driving either a real car or a close simulation because the form of static driving instructions is much different from real time instructions. Given some a priori knowledge about the ways that a route can be described, it is not impossible that the system could understand the instructions, and infer style from it. A difficulty here is that if the driver knows the route well, many things will seem obvious to her that would not be obvious to another person.

If the Back Seat Driver knows what the driver knows about the city, it can give better directions. A user who knows about a city no longer need instructions, she needs information about structure. The object description system preferably provides novice users a process description which emphasizes casual connections, and experts structural descriptions. Experts do not need the casual information, they can derive it for themselves.

The attributes of the user-model preferably include:

route-preference—does the driver want the fastest, shortest, or simplest route?

reassurance-period—how often should the program speak to the driver?

use-names—should the program tell the driver the names of passing streets?

congratulate-after-act—should the program make an explicity acknowledgment of correctness to the driver after each act?

obvious-to-cross-major—can the program assume that the driver will continue straight across a major intersection without being told explicitly to do so?

scoflaw—does the driver want to be warned when she is speeding?

daredevil—does the driver want warnings when driving dangerously fast?

distance-lowpass—does the driver want to be told the distance to the next action (in yards or miles, as appropriate). Most drivers do not understand distances in tenths of miles, so by default the program mentions only those distances that exceed one half mile.

The functions of the user-model preferably include:

obvious-next-segment—given a current position, is there a unique segment such that it is almost certain the driver will go there, without being told to do so?

at-major-intersection—is the current intersection one that the driver would call "major"?

extrapolate-path—try to predict the path the driver will follow in the next N seconds, assuming she does only what is obvious.

maximum-safe-speed—calculate the maximum speed at which the driver can get through an intersection. This calculation is based on finding the segment with the greatest radius of turn, and then calculating the largest speed the vehicle could have while making that turn without undergoing unacceptable sideways acceleration.

For the Back Seat Driver to decide what to say and when to say it, it preferably has a model of the vehicle performance. It must know, for example, how slowly the car should be going in order to safely make a turn. A suitably instrumented car could also measure the coefficient of friction by comparing the applied braking force and the resulting deceleration. This would allow it to adjust the time factors used in deciding when to speak.

The Back Seat Driver should understand the driver's plans and goals. When a driver enters a destination address, she is telling the system that she has the goal of getting to that address. The Back Seat Driver might guess at higher level plans from knowledge about the destination, and take actions to assist the driver with those plans. To do this, it must know what kind of thing is at the destination address. For instance, if the address provided is that of a store, the Back Seat Driver can guess that the driver is going there to purchase something, or at least to do business there. It could check the hours that the store is open.

The Back Seat Driver should help drivers to understand the route it gives. This would make the system more pleasant to use. It would also make it easier to follow routes because a driver who understands the route and the city will use that knowledge to help interpret the commands Back Seat Driver gives. A route should fit into a larger model of the city. This means that the Back Seat Driver itself must have a model of the city and should speak of the route in terms that relate it to the city. There are several opportunities to do this. At the beginning of the route, the driver might hear an overview of the route, naming the major paths followed and neighborhoods crossed. During the route, locations could be described not just as street address but in larger units of neighborhoods and districts. Orienting information can be included in instructions, or it might come between instructions, as a passing comment.

There are some additional services that the Back Seat Driver could easily provide. It should be able to give the location of a place without giving directions, it should be able to give the directions all at once, and it should be able to give directions between any two places. A driver might want to use these to tell someone else how to get to where they are.

The Back Seat Driver should be able to communicate with the outside world if the outside world is equipped to talk to it. For instance, after determining that a given parking garage is the closest or most convenient to the current destination, the Back Seat Driver could automatically phone or radio the garage and reserve a space.

The Back Seat Driver should be running on a computer embedded in the car, so that it can get more and better information about the state of the car and driver. For instance, when the next instruction is a turn, the Back Seat Driver should notice whether and when the driver turns on the turn signals. If the driver applies them too soon, it is possible (but not certain) that the driver has underestimated the distance to the turn; if applied at the "right time" then the system can take that the action has been understood; if never applied, then the driver has either misunderstood, or is driving hazardously.

The Back Seat Driver should also be integrated into the car's audio system, rather than having separate systems for voice and music. Furthermore, it should pay attention to what the driver is listening to. If the driver is listening to the radio, or playing a CD (or using a cellular telephone) the program should try to speak less often, on the grounds that the driver has implicitly indicated a preference for what to listen to. The program should suppress reminders and historical notes altogether. When it must speak, it should borrow the audio channel rather than trying to speak over it. The Back Seat Driver should also be aware of the driver's use of other controls in the car. It should defer speech

while the driver is adjusting the heat or the mirrors, for example, and suppress speaking altogether if the car makes sudden extreme changes in velocity. A driver trying to cope with an emergency situation does not need another distraction.

The discourse model preferred for the Back Seat Driver is a partial implementation of the discourse theory described by B. J. Grosz and C. L. Sidner ("Attention, intentions, and the structure of discourse" in *Computational Linguistics,* 12(3):175–204, 1986) and the theory of intonational meaning described by J. Hirschberg and J. Pierrehumbert ("The intonational structuring of discourse" in *Proceedings of the Association for Computational Linguistics,* 136–144, July 1986). Both of these articles are herein incorporated by reference. This model allows the program (or programmer) to create and manipulate discourse segments. The program specifies the contents of the discourse segment (both the syntactic form and the list of objects referenced) and the implementation of the model does the following: generates prosodic features to convey discourse structure; inserts discourse segment into intentional structure; and maintains attentional structure—adding new objects when mentioned and removing old objects when replaced. In addition it includes some useful low-level tools for natural language generation: search of attentional structure for occurence of co-referential objects; conjugation of verbs; generation of contracted forms; and, combination of sentences as "justification" sentences (e.g. "get in the right lane because you are going to take a right.") and sequential sentences ("Go three blocks, then turn left"). In order to use the discourse package the programmer must explicitly declare all semantic types used by the program, so in this case there are declarations for all objects which pertain to driving, such as street names, bridges, rotaries, stop lights and so on.

SPEECH GENERATOR

In the working prototypes of the Back Seat Driver, speech generation is performed by Dectalk, a commercial text-to-speech speech synthesizer, which is cabled to the main computing apparatus.

An alternative to synthesized speech is digitized speech, which is easier to understand than synthetic speech. Digitized speech, however, requires a great deal of storage space. There are more than 2000 different street names in Boston. Allowing another 500 words for the actual instructions, and assuming an average duration of 0.5 seconds for each word, coding this vocabulary at 64 kilobits per second would require 10 megabytes of speech storage. Given a Back Seat Driver that uses a CD-ROM for the map, the digitized speech could be stored on the disk as well. Coded speech would be more intelligible than synthesized speech, and less costly, but not as flexible. For, example, it would be impossible to read electronic mail using only stored vocabulary speech.

The generated speech is spoken to the driver through some kind of speaker system in the car. In a simple embodiment, the speaker system of the car radio is used.

DRIVER INPUT MEANS

Means for the driver to communicate with the back-seat driver are required. For example, the driver must be able to enter destination addresses, request instructions or a repeat of instruction, and inform the Back Seat driver when an instruction cannot be carried out for some reason. In embodiments where the computing apparatus is installed in the automobile, a computer keyboard can be adapted to provide this communication means.

In one working prototype of the Back Seat Driver, the computing apparatus is not installed in the automobile, but is accessed through a cellular telephone. In this embodiment, the driver communicates with the Back Seat Driver by using the cellular telephone keypad. Address entry is achieved by first entering the digits, then a number sign, then spelling the street name using the letters on the telephone keypad. The letters "Q" and "Z" are on the "6" and "9" keys, respectively, and the space character is on "1", which is otherwise unused. These keys are sufficient to spell any street name in Boston. The spelling rules can be easily expanded to enter street names with other characters in them, for example, "4th Street".

In the implementation, spelling a street name requires only one button push for each letter, even though there are three letters on each key. This is because of the redundancy in street names, which are pronounceable words, not arbitrary strings. There are 37 pairs of street names in Boston with the same "spelling" in the reduced "alphabet". An example is "Flint" and "Eliot", both encoded as "35468". This is only one percent of the 2628 names of streets in Boston, so collisions are rare. This technique appears workable even for larger sets of names. When the entire word list of the Brown corpus is encoded, there are still only 1095 collisions in the 19,837 words (5.5%).

If a name collision occurs, the Back Seat Driver reads the list of possibilities, and asks the driver which one was meant. This is very rare. A more common problem is that street names are duplicated. When this happens, the Back Seat Driver asks the user a series of questions to reduce the list to a single choice. It tries to ask the fewest questions possible. It asks the user to choose from a list of street types, if that is sufficent to resolve the question, and otherwise from a list of the containing cities (or neighborhoods, if there are two instances within a single city). To select from a list, the Back Seat Driver reads the contents, asking the user to push a button when the desired choice is read.

The Back Seat Driver would be much easier to use if the driver could simply talk to it instead of using a keyboard or keypad. Speech recognition could be used for driver input means, however, address entry is a difficult task for speech recognition for the same reason it is hard for a human to understand machine speech—there are few constraints on a name. No speech recognizer available today can handle a 3000 word vocabulary with acceptable error rates. The car would also have to be stopped while the driver was speaking, because noise in moving cars for frequencies below 400 Hz can exceed 80 dB.

Back Seat Driver could also use speech recognition to replace the "What now?" and "What next?" buttons. This is a more tolerant application for speech recognition because there are fewer words to recognize.

SYSTEM PROCESSES

The Back Seat Driver carries out three separate tasks, each of which is executed by its own process. All processes share the same address space, so all variables and functions are accessible in every process, and no special mechanism for interprocedure call is required. Where necessary for synchronization, Back Seat Driver uses

queues or locks. All three processes are simple, infinite loops. The system processes are illustrated in FIG. 2.

The user process is the main process of the Back Seat Driver. It is this process which finds routes and gives instructions to the driver. The user process manages a list of goals. Each time around the loop, it selects a goal to work on, and does something to achieve the goal, if possible. The user process is connected to the speech generator, since that is how it talks to the driver.

The navigator process maintains an estimate of the current position and velocity of the car. It is connected to the position sensor by a serial line. Preferably, packets arrive from the position sensor several times a second. The navigator converts the data in the packets from the position sensor format to the format used by the Back Seat Driver.

There are two minor processes which assist the navigator process: The average speed process computes the running average speed of the vehicle over the last five seconds. It could be made part of the navigator process, but is distinct because it is more convenient that way. The position sensor monitor process keeps track of how often packets arrive. If packets do not arrive when scheduled, it should set a flag to indicate this to inform the driver if the position sensor ceases to work properly.

The control process is responsible for controlling the Back Seat Driver as a whole. The control process is connected to driver input means for entering, for example, the destination and requesting additional instructions while driving (e.g. the "What now"?, "What next?" and "I can't do it" features.) Other functions of the control process are useful in a research prototype, but should not be required in a commercial embodiment of the Back Seat Driver. One such function is debugging.

The user process is a goal-driven perpetual loop which seeks to use the resources available to it to satisfy as many goals as possible as quickly as possible, devoting resources first to those goals which are of greatest importance. There are two aspects to this process, goal structures (which names goals) and goal-functions (which tell how to accomplish them). A goal is just a name, a priority (a number), and a set of slots (parameters). Thus for instance a typical goal would be (GET-TO-PLACE <140 Elm Street>), where the goal has one slot, namely the destination. A goal-function is a function which is possibly able to achieve a goal. When a new type of goal is defined, the programmer also tells the system which goal functions can possibly meet it, and later, when the system tries to accomplish a goal it selects from this list.

The goal loop is a three step process. 1) Check to see whether there are any newly added goals. The driver can add a goal by hitting a key, and the system can also add goals. 2) Find the most important goal to work on. 3) Work on that goal. In general, systems should use resources in the most efficient manner possible. For the Back Seat Driver, the only resource is speaking time. The only way the Back Seat Driver can accomplish any of its goals is by speaking. Speech is a resource because the program can only say one thing at a time, and speaking takes a finite time. It is also important to note that spoken utterance has a useful effect only if completely spoken, so it is not helpful to begin to speak if there is not time to complete the speech.

The protocol for a goal function preferably includes the following:

progressable?—Is the goal able to accomplish anything at this time?

resource-used—If it runs now, what resources will it want to use?

maximum-time-of-resource—If it runs now, how long (in seconds) will it need each resource?

minimum-time-to-resource—The minimum time that it can estimate until it may again need this resource, and the priority of its use at that time.

In the working prototypes of the Back Seat Driver, the list of all goals is stored in the global variable *goals*. The goal loop and goal structures are defined in the file goals.lisp. The various goals and goal functions of the Back Seat Driver are defined in the files main.lisp, route-goals.lisp, and get-to-place.lisp. All goals which use speech are built from the speech-goal object defined in speech-goal.lisp. The speech resource itself is defined in speech-resource.lisp.

The goal or function which gets a user to a destination is called GET-TO-PLACE. An explanation of this goal will illustrate the goal mechanism in more detail, as well as illustrate how this most important function of Back Seat Driver is implemented. The goal GET-TO-PLACE, has two slots, destination which is the location the user wants to get to, and route which is the route the Back Seat Driver intends to use to get there.

The driver adds the goal to the system goal list by striking a key. When the goal is first created, the destination is not known (the destination slot is empty), so the goal function for GET-TO-PLACE creates a sub-goal, GET-DESTINATION, and adds it to the goal list. Now there are two goals on the goal list, GET-TO-PLACE and GET-DESTINATION, but only the second is progressable, because when a goal has a sub-goal, it is not allowed to run until the sub-goal finishes. Therefore, the only progressable goal is GET-DESTINATION, which attempts to get a destination by asking the user to enter an address. If the user fails to do so, the subgoal fails, which in turn causes GET-TO-PLACE to fail, and the Back Seat Driver says "Travel cancelled". Otherwise, it writes the destination into the destination slot of the GET-TO-PLACE goal. Now that the sub-goal is complete, GET-TO-PLACE can once again make progress. This time it finds that the route slot is empty, and again calls for the sub-goal GET-ROUTE, which calculates a route. When this is complete a third subgoal is invoked, namely FOLLOW-ROUTE.

The goal function for FOLLOW-ROUTE gets the driver to the destination by speaking instructions. If something goes wrong (for example if the driver makes a mistake) then the subgoal fails. But this does not make GET-TO-PLACE give up. Instead, it erases the route slot, and simply finds a new route, and then tries FOLLOW-ROUTE again. This continues, no matter how many times things go astray, until either FOLLOW-ROUTE succeeds, or the driver cancels the trip.

The goal FIND-SERVICE is similar to GET-TO-PLACE except the driver selects a kind of service (for example, a gas station), and then the Back Seat Driver finds the closest provider of that service, and then finds a route to it. Following that route is done by FOLLOW-ROUTE in the same way as for GET-TO-PLACE.

The FOLLOW-ROUTE goal function gets the user to her destination by giving spoken instructions. There are several reasons it might speak:

at the beginning, to alert the driver

to give an instruction in advance, so the driver will be ready

to give an instruction when it is time to do it

to confirm that the driver has correctly carried out an instruction

to inform the driver of her arrival at the destination

to reassure the driver that she is still on route

to inform the driver of a mistake

to warn the driver that she is driving so fast that the program cannot keep up.

FOLLOW-ROUTE decides the next reason for speaking by first trying to locate the current position on the path. If the position is not on the path (more precisely, if the current segment does not occur anywhere on the path) then the driver has left the path (or the position sensor has made an error). Otherwise, FOLLOW-ROUTE determines what instruction must be next executed by calling the function next-driver-instruction.

The goal function protocol requires that FOLLOW-ROUTE support the goal function minimum-time-to-resource, which estimates the minimum time until FOLLOW-ROUTE will next speak. This time depends upon the reason for the next speaking. FOLLOW-ROUTE speaks immediately when beginning, confirming, warning, or finishing the route. When the driver is off the route, FOLLOW-ROUTE waits a few seconds before speaking, just in case the driver's departure from the route is actually a temporary error by the position sensor.

Given that the driver is on the path, FOLLOW-ROUTE determines when to speak by calculating the position where it must begin speaking the instruction text, then estimating the time required to reach that position at the driver's current speed. As the driver's speed changes, so will this estimated time. The position to begin speaking is calculated by first finding the position where the instruction is executed, then moving back a distance to allow the Back Seat Driver time to speak the text and the driver to react to it.

The Back Seat Driver can also give instructions in advance, if desired. It does this in much the same way, except that it adds an additional number of seconds (normally thirty) to the time estimate, and so begins to speak much sooner. When it gives instructions in advance the instruction text is longer because the program has more time to speak.

When the driver leaves the route FOLLOW-ROUTE starts a timer. If the driver has not returned to the route by the time the timer goes off (at present, two seconds) then FOLLOW-ROUTE checks for a possible mistake. In describing the mistake, it attempts to characterize what the driver actually did as well as what the program intended the driver to do. It is able to do this because in the main loop it stored the last position that the driver was on when last on the route.

Goals may interrupt lower priority goals by requesting the speech resource to interrupt the lower priority goal. Interruption stops the speech synthesizer immediately. The interrupted goal is informed of the interruption, and can react as it chooses. There is no way for the goal to know whether any of its words were actually spoken, so it has to start all over. Most goals attempt to run again as soon as possible. The assumption is that the interruption occurred because the user started some higher priority goal after learning how to do so through the help command.

The system treats "repeat the last statement" as a goal, rather than as a special purpose function, except that the importance of this goal is set to the value of the last goal spoken (the goal whose utterance is being repeated). This guarantees that if some more important goal desires to speak, it will be able to. A repetition of an utterance is no more important than it was originally.

Goals can be temporary or presistent. Temporary goals can be satisified, but persistent goals never can be. All system initiated goals are persistent. The system goals include warning the driver of dangers ahead (WARN-DRIVER) and informing the user of new electronic mail or other messages (if the computer apparatus of the Back Seat Driver is connected to the outside world). These goals can never be satisified. The driver's safety should always be preserved and mail or messages can arrive at any time.

CELLULAR PHONE EMBODIMENT

The Back Seat Driver is preferably an in-car navigation system, but in some embodiments, it may be desirable to not have the entire computing apparatus installed in the car. This is the case if the computing apparatus is too large or if a number of cars are to share a single computing apparatus.

For such embodiments, two cellular phones installed in the car can be used to transmit data from the car to the computing apparatus, and to receive voice from the speech generator in the computing apparatus. In this embodiment, data from the position sensor installed in the automobile is sent through a cellular phone in the car equipped with a modem to a phone connected to the computing apparatus via a modem. The voice generating apparatus of the computing apparatus sends speech over another phone to a second cellular phone installed in the automobile.

This embodiment has been implemented in a working prototype, using a large workstation computer (a Symbolics Lisp Machine). In this implementation, a position sensor installed in the car estimates vehicle position, heading, and velocity, and sends a data packet, once per second, through a modem to the workstation. The workstation sends characters to a Dectalk speech synthesizer, which in turn sends voice over a second phone to the driver.

Nearly everyone who has used a cellular phone knows how noisy they are. Cross talk is common and noise bursts and signal loss make it hard to hear. A sufficiently bad noise burst can even cause the cellular system to terminate the call. The problems for data transmission are even worse. By its very nature, cellular radio transmission is subject to multi-path interference, which causes periodic fades as the antenna moves in and out of anti-nodes. In addition to this fading, there is a complete loss of audio signal for as long as 0.9 seconds when the phone switches from one cell site to another (hand off).

An attempt to use an ordinary (land-line) modem from the car was unsuccessful. In the prototype, a Worldlink 1200 from Touchbase Systems was used in the car, with a Morrison and Dempsey AB1 data adapter, and an NEC P9100 phone, boosted to 3 watts. At the base station, both a Practical Peripherals 2400 and a Hayes Smartmodel 1200 were used. Even at 300 baud the connection was too noisy to use. Worse, connections seldom lasted more than five minutes. In all cases, the "loss of carrier" register (S10) was set to its maximum value, 20 seconds. Loss of carrier signal alone

cannot explain why the connections dropped. The modems were capable of tolerating a complete loss of audio for up to twenty seconds.

Better results were found using an error correcting modem (The "Bridge") made by the Spectrum Cellular Corporation. This modem uses a proprietary protocol (SPCL) for error correction. The Spectrum product virtually eliminated noise, at the price of a lower data transmission rate. According to the protocol, the transmitting modem groups characters into packets that include error correction bytes. If only a few errors occur, the receiving modem repairs the data and acknowledge receipt. If there are many errors, the packet is retransmitted. If the sending modem has to retransmit too often it makes the packets smaller, on the assumption that a smaller packet has a better chance of success. This is less efficient, since packets have a fixed overhead, the percent of the channel used by data decreases. When conditions improve the modem increases packet size again. In theory, the modem can transmit at 120 characters per second, but tests made by recording the time required to receive the three characters of an odometer sequence demonstrated that the average value is closer to 30 characters per second. This sequence is transmitted once per second. The mean for durations for the three character sequences is 94 milliseconds, which is 31 milliseconds per character, or 32 characters per second.

Even with the cellular modem, calls are sometimes dropped. The call durations are usually long enough for a successful trip with the Back Seat Driver. Voice calls are dropped at about the same rate as data calls.

The protocol used by the Spectrum modem acknowledges all data transmitted. If the acknowledgment is not received, it retransmits the data until acknowledged. Under adverse conditions, this can result in an arbitrarily long delay. This is a problem when real-time data is transmitted. Observation of the Back Seat Driver shows that sometimes the system will "freeze" for from one to ten seconds. During this time, the car of course continues to move. If these freezes occur near decision points, the driver may go past the intersection without being told what to do. At 20 miles per hours a car travels nearly 45 meters in five seconds. The navigation system in the car sends a packet once every second. Most packets arrive within a second, but a few are delayed, some by up to ten seconds. (These delays may also arise from delays at the workstation. Lisp Machines are not noted for real-time response.)

It would be better to have a protocol which guarantees to deliver data intact and free of errors, if it delivers it at all, but does not guarantee to deliver the data. Real time data is only valuable in real time, and time spent retransmitting old data is taken away from ever, more valuable data. Such a protocol modification is feasible for the Spectrum product.

What is claimed is:

1. An automobile navigation system which produces spoken instructions to direct a driver of an automobile to a destination in real time comprising:

computing apparatus for running and coordinating system processes,

driver input means functionally connected to said computing apparatus for entering data into said computing apparatus, said data including a desired destination,

a map database functionally connected to said computing apparatus which distinguishes between physical and legal connectivity.

position sensing apparatus installed in the automobile and functionally connected to said computing apparatus for providing said computing apparatus data for determining the automobile's current position,

a location system functionally connected to said computing apparatus for accepting data from said position sensing apparatus, for consulting said map database, and for determining the automobile's current position relative to the map database,

a route-finder functionally connected to said computing apparatus, for accepting the desired destination from said driver input means and the current position from said location system, for consulting said map database, and for computing a route to the destination,

a discourse generator functionally connected to said computing apparatus for accepting the current position from said location system and the route from said route finder, for consulting said map database, and for composing discourse including instructions and other messages for directing the driver to the destination from the current position,

a speech generator functionally connected to said discourse generator for generating speech from said discourse provided by said discourse generator, and

voice apparatus functionally connected to said speech generator for communicating said speech provided by said speech generator to said driver.

2. The automobile navigation system of claim 1 wherein said map database comprises a set of straight line segments and a set of nodes, each endpoint of each segment being a pointer to a node representing the coordinates of the endpoint and the set of other segments which are physically and legally connected to that endpoint.

3. The automobile navigation system of claim 1 wherein said map database is based on DIME files of the United States Census extended to represent physical and legal connectivity.

4. The automobile navigation system of claim 3 wherein said DIME file is further extended to distinguish bridges, underpasses, tunnels, rotaries, and access ramps from other street types.

5. The automobile navigation system of claim 1 wherein said map database is based on TIGER files of the United States Census and United States Geological Survey extended to represent physical and legal connectivity.

6. The automobile navigation system of claim 5 wherein said TIGER file is further extended to distinguish bridges, underpasses, tunnels, rotaries, and access ramps, from other street types.

7. The automobile navigation system of claim 1 wherein said map database comprises a three-dimensional representation of street topology.

8. The automobile navigation system of claim 1 wherein said map database includes measures of street quality.

9. The automobile navigation system of claim 1 wherein said map database distinguishes divided streets.

10. The automobile navigation system of claim 1 wherein said map database includes landmarks such as signs, traffic lights, stop signs and buildings.

11. The automobile navigation system of claim 1 wherein said map database includes lane information.

12. The automobile navigation system of claim 1 wherein said map database includes speed limits.

13. The automobile navigation system of claim 1 wherein said map database includes expected rate of travel.

14. The automobile navigation system of claim 1 wherein said map database includes time-dependent legal connectivity.

15. The automobile navigation system of claim 1 wherein said map database includes turn difficulty.

16. The automobile navigation system of claim 1 wherein said map database includes vehicle street, lane, and height restrictions.

17. The automobile navigation system of claim 1 wherein said map database includes traffic light cycles.

18. The automobile navigation system of claim 1 wherein said map database distinguishes where right turn on red is allowed.

19. The automobile navigation system of claim 1 wherein said map database includes a database of service locations.

20. The automobile navigation system of claim 1 wherein said map database includes a listing of famous places by name.

21. The automobile navigation system of claim 1 further comprising means for updating said map database.

22. The automobile navigation system of claim 1 further comprising means for updating said map database by radio broadcast.

23. The automobile navigation system of claim 1 wherein the map has minimum accuracy of 10 meters.

24. The automobile navigation system of claim 1 wherein said route finder is based on a best-first search algorithm.

25. The automobile navigation system of claim 1 wherein said route finder is based on an A* algorithm.

26. The automobile navigation system of claim 1 wherein said route finder is based on an A* algorithm modified to find a route in less time.

27. The automobile navigation system of claim 1 wherein said route finder is adapted to find a best route according to any one of three cost metrics: distance, speed, simplicity.

28. The automobile navigation system of claim 1 wherein said route finder is adapted to calculate a new route if the driver or vehicle navigation system makes an error or if the route is unnavigable due to unforeseen circumstances, wherein said new route does not simply backtrack to the point of the error if a better route from the current location exists.

29. The automobile navigation system of claim 1 wherein said route finder is adapted to calculate a new route while the automobile is in motion, wherein said new route will begin from the location of the automobile at the time the calculation of the new route is completed.

30. The automobile navigation system of claim 29 wherein an estimated time to find a new route is multiplied by the velocity of the automobile to calculate the position from which the new route should start.

31. The automobile navigation system of claim 30 wherein said estimated time to find a new route is calculated by multiplying the distance between the starting and ending points of the new route by a constant.

32. The automobile navigation system of claim 1 wherein said location system is a position-keeping (dead-reckoning) system.

33. The automobile navigation system of claim 1 wherein said location system is a hybrid of position-keeping and position-finding systems.

34. The automobile navigation system of claim 1 wherein said location system employs map matching.

35. The automobile navigation system of claim 1 wherein said position sensing apparatus comprises displacement and direction sensors installed in the automobile.

36. The automobile navigation system of claim 1 wherein said position sensing apparatus measures displacement with an odometer.

37. The automobile navigation system of claim 1 wherein said position sensing apparatus measures direction with a magnetic compass.

38. The automobile navigation system of claim 1 wherein said position sensing apparatus measures direction by monitoring the turning of the steering wheel.

39. The automobile navigation system of claim 1 wherein said position sensing apparatus measures direction with a differential odometer.

40. The automobile navigation system of claim 1 wherein said position sensing apparatus measures direction with a gyroscope.

41. The automobile navigation system of claim 1 wherein said discourse generator is based on an object-oriented programming methodology.

42. The automobile navigation system of claim 1 wherein each intersection in a route is classified into one type in a taxonomy of intersection types, and the disclosure generated in relation to each said intersection depends on its type.

43. The automobile navigation system of claim 42 wherein said taxonomy of intersection types includes continue, forced-turn, U-turn, enter, exit, onto-rotary, stay-on-rotary, exit-rotary, fork, turn, and stop.

44. The automobile navigation system of claim 42 wherein said discourse generated further depends on a description function for each intersection type which generates a description given the length and tense of the desired description and the position along the route from which an instruction is to be given.

45. The automobile navigation system of claim 1 wherein said discourse generated comprises a long description of an act given substantially before the act is to be performed and a short description given at the time the act is to be performed.

46. The automobile navigation system of claim 45 wherein said long descriptions includes cues.

47. The automobile navigation system of claim 46 wherein said cue is a landmark.

48. The automobile navigation system of claim 1 wherein said driver input means includes means for said driver to demand immediate instructions, or clarification or repetition of instructions already provided.

49. The automobile navigation system of claim 1 wherein said driver input means includes means for said driver to indicate to said automobile navigation system that a given instruction provided by said system is impossible to complete for some reason and that a new route must be calculated.

50. The automobile navigation system of claim 1 wherein said driver input means comprises a voice recognition system to allow at least some driver input to be spoken.

51. The automobile navigation system of claim 1 wherein said automobile navigation system records a history of the route and the discourse already generated and uses this knowledge to generate cues for future discourse and make future discourse more understandable.

52. The automobile navigation system of claim 1 wherein said automobile navigation system warns drivers of dangers inferred from knowledge of the road network.

53. The automobile navigation system of claim 1 wherein said automobile navigation system informs a driver if an error has been made as detected by the location system.

54. The automobile navigation system of claim 1 wherein said discourse generator is responsive to a user-model stored in said computing apparatus to customize discourse to the requirements and preferences of said driver.

55. The automobile navigation system of claim 1 wherein said speech generator is a speech synthesizer.

56. The automobile navigation system of claim 1 wherein said speech generator uses digitized speech.

57. The automobile navigation system of claim 1 wherein said computing apparatus is not installed in the automobile, and said automobile navigation system further comprises means for communication between said computing apparatus and the automobile navigation system components installed in the automobile.

58. The automobile navigation system of claim 57 wherein said means for communication is two cellular phones in said automobile, one of which is connected to a modem, and two phones connected to said computing apparatus, one of which is connected to a modem, whereby one data channel and one voice channel between said automobile and said computing apparatus is created.

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UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 5,177,685 Page 1 of 2

DATED : January 5, 1993

INVENTOR(S) : James R. Davis, et al.

It is certified that error appears in the above-indentified patent and that said Letters Patent is hereby corrected as shown below:

Column 1, line 18: after "all" please insert "three";

Column 7, line 50: delete "street" and insert therefor -- streets --;

Column 11, line 11: after "algorithm" please insert ", ";

Column 11, line 66: after "compass" and before "A" please insert ": ";

Column 12, line 4: after "wheel" and before "The" please insert ": ";

Column 12, line 6: after "odometer" please insert ": ";

Column 12, line 14: after "gyroscope" and before "Gyroscope" please insert ": ";

Column 16, line 36: delete "to also" and insert therefor -- also to --;

Column 17, line 18: delete "its" and insert therefor --it is --.

Column 17, line 18: delete "that";

Column 17, line 20: delete "if" and insert therefor -- is --;

Column 17, line 18, delete "it".

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Page 2 of 2

It is certified that error appears in the above-indentified patent and that said Letters Patent is hereby corrected as shown below:

Column 18, line 61: delete "work" and insert therefor -- word --;

Column 21, line 16: delete "need" and insert therefor -- needs --;

Column 21, line 19: delete "casual" and insert therefor -- causal --;

Column 21, line 21: delete "casual" and insert therefor -- causal --;

Column 28, line 8: delete "presistent" and insert therefor -- persistent --;

Column 29, line 13: delete "knowledge" and insert therefor -- knowledges --;

Column 32, line 33-34: delete "disclosure" and insert therefor -- discourse --; and

Column 32, line 52: delete "includes" and insert therefor -- include --.

Signed and Sealed this

Fifteenth Day of March, 1994

Attest:

Bruce Lehman

BRUCE LEHMAN

Attesting Officer

Commissioner of Patents and Trademarks

EXHIBIT 2

Back Seat Driver: voice assisted automobile navigation

by

James Raymond Davis

B.S.A.D., Massachusetts Institute of Technology (1977)

Submitted to the Media Arts and Sciences Section
in partial fulfillment of the requirements for the degree of

Doctor of Philosophy

at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

September 1989

Signature of Author . . . .
Media Arts and Sciences Section
August 4, 1989

Certified by . . . .
Nicholas P. Negroponte
Professor of Media Technology
Thesis Supervisor

Accepted by . . . .
Stephen A. Benton
Chairman, Departmental Committee on Graduate Students

Back Seat Driver: voice assisted automobile navigation

by

James Raymond Davis

Submitted to the Media Arts and Sciences Section
on August 4, 1989, in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy

Abstract

The Back Seat Driver is a computer navigation assistant for drivers in a city. It differs from earlier navigation programs by using speech, rather than graphics, to give instructions. The advantages of speech are that the driver's eyes are left free for driving and that the spoken directions contain information not easily portrayed in pictures. The program talks about the features of the road in the same way the driver sees them, giving the impression that the program is actually is in the car.

Driving instructions are modeled after those given by people. The two issues for spoken directions are *what to say* (content) and *when to say it* (timing). The content of the instructions tells the driver what to do and where to do it. The program has a large taxonomy of intersection types, and chooses verbs to indicate the kind of intersection and the way of moving through it. The instructions refer to landmarks and timing to tell the driver when to act.

Timing is critical because speech is transient. Drivers hear instructions just in time to take the required action, and thus need not remember the instruction or exert effort looking for the place to act. The program also gives instructions in advance, if time allows, and the driver may request additional instructions at any time. If the driver makes a mistake the program describes the mistake, without casting blame, then finds a new route from the current location.

Street map data bases for navigation programs must distinguish between *physical* connectivity (how pieces of pavement connect) and *legal* connectivity (whether one can legally drive onto a physically connected piece of pavement). Legal connectivity is essential for route finding, and physical connectivity for describing the route. The database must also contain all landmark information, since the program has no "eyes".

Acknowledgments

I owe gratitude to many people for help with this work. In particular I would like to thank: Phil Rittmueller and NEC Home Electronics (USA) Inc., who sponsored it; Symbolics Inc., Digital Equipment Corporation, the Nippon Telephone and Telegraph company, and DARPA, which sponsored my earlier graduate studies; Brewster Kahle, who provided the original inspiration for my work on computerized direction giving in the summer of 1985; Thinking Machine Corporation, where the work was conducted; and Tom Trobaugh, who began that study with me. I thank those who provided me with helpful information: James A. O'Connell, Jr. and Peter Naghavi of the Somerville Department of Traffic and Parking, Jane Kent of the Cambridge Department of Traffic, and George Hawat of the Boston Transportation Department, for providing traffic light data bases; Doris Walter of the Massachusetts District Commission for maps of rotaries; Doug Milliken for explanations of car dynamics; Don Cooke of Geographic Data Technology and Joel Sobel of the Census Bureau for information on the DIME and TIGER map formats; David Pietraszewski of the United States Coast Guard and Michael Fisher of Trimble Navigation for information about GPS. The photo on page 60 was taken by Kyle G. Peltonen, and is reprinted by permission of The Tech, the Mr. Boffo cartoon is reprinted courtesy of the Tribune Media Services. I thank also Weng-yew Ko for building hardware interfaces; Elaine McNair at NEC for removing many obstacles; Michael Sullivan of Spectrum Communication for solving communications problems; Greg Parro of Cellular Phone Services for excellent service with the tele-

phones; Hidehiro Matsumoto of NEC for translations to and from the Japanese; Janette Noss and Elaine McCarthy, who keep the Architecture Machine Group running; Anna Korteweg, Walter Bender, Gary Drescher, and Carol Strohecker for careful editing, and Shawn T. Williams and Greg Grove, who helped by participating in UROP work. I wish to thank all those who taught me of computational linguistics, especially Barbara Grosz, Julia Hirschberg, and Janet Pierrehumbert. They of course bear no responsibility for my failure to fully grasp the material they attempted to teach me. My committee members were Steven Benton, Mike Lesk, Nicholas Negroponte, and Chris Schmandt. None of these people, of course, are responsible in any way for the ways I have misunderstood their ideas or abused their work, or for my failure to heed their advice. Finally I must specially mention Nicholas Negroponte, who created the Media Lab where this work was possible, and Chris Schmandt, the director of the Speech Research Group, who has been directly involved in everything I have done here at the Media Lab. A full list of his contributions to my studies would require many pages.

Those I have forgotten or otherwise neglected, I can only ask to deepen my debt by forgiving my shoddy memory and inexpressive words.

This thesis is dedicated to my son, Adam, may he find his way back soon.

Chapter 1

Overview

This thesis is about the design and construction of a machine that does something difficult and useful in a new way. The machine's purpose is help people find their way by car from one place to another within a city, a task which is clearly useful and also worth improvement. A study done for the United States Federal Highway Administration estimated that 45 billion dollars are wasted each year in the U.S. because of ineffective routing, from causes including being lost, stuck in traffic, or choosing bad routes[1]. The machine discussed here is called the **Back Seat Driver**[1]. The Back Seat Driver is a computer program which uses synthetic speech to give instructions to the driver of a car as needed while driving. The Back Seat Driver differs from previous navigation assistance programs by using speech to give directions[2], instead of drawing a map or displaying symbols.

My two concerns are to determine the best form and content for spoken instructions, and to determine what information a program requires in its map to find routes and provide excellent instructions. My approach towards both questions is

[1] The usual sense of this term is an unwanted critic of one's driving skills. This is not what I intend.

[2] Although there are reports of earlier navigation systems using speech, none are described in the literature.

A FORCED TURN is an intersection where there is only one next street segment where the road bends more than 10 degrees. Even though there is no decision to make at a forced turn, it is useful to mention because it strengthens the driver's sense that the Back Seat Driver really knows about the road conditions. (It may be helpful to think of "obvious" as meaning "worth mentioning". It is worth mentioning a bend in the road, even though it is also obvious that one stays on the road.) The natural directions collected at the start of this study also included examples of "forced turns". A forced turn is not worth mentioning if both segments are part of a bridge, a tunnel, or an access ramp, or if the angle is less than 20 degrees. The intent here is to estimate whether the driver can see the continuation.

The TURN AROUND action is recognized when the heading of the car is the opposite of what it should be. Recall that a route is a sequence of segments and endpoints. At all times the car will be on one of the segments in the sequence. If the car's orientation is not the same as the endpoint in the path, then the driver must turn around. Note that the route finder only calls for a U Turn if there is no other way (e.g. when facing into a dead-end street).

The next four actions depend heavily on the street type and street quality in order to be recognized correctly. This must be emphasized because these features are not always present in digital street maps, yet without them, these acts can not be identified. (One could imagine attempting to infer the presence of a rotary from the geometry of streets in a map. It seems very difficult.)

To ENTER is to move onto a super street (or an access ramp that leads eventually to a super street) from an ordinary street, but not from a super street or an earlier access ramp. Similarly, to EXIT is to move from a "super" quality street onto a street with lesser quality that is either an access ramp or has a different name. The extra condition is needed because some "super" roads are not uniformly "super": for instance, the McGrath Highway in Somerville is a limited access road in places, but has stoplights at other places. It would not be right to call the

kinds of navigation service:

- **positional** systems tell you where you are.
- **orienting** systems show the direction of your destination.
- **instructional** systems tell you what to do.

A navigation system can provide one, two, or all of these services. Navigation systems can be further distinguished by how they provide the information:

- **verbal** systems speak.
- **text** systems provide text.
- **graphic** systems provide pictures.

Finally, systems can be classified as either **real time** or **static**. The categories of this classification are not independent. There can be no static positioning system, since one can not predict the future position of the car.

The systems of Elliot and Lesk, Ma, and Hertz provide static, text instructions. Direction Assistance gives static verbal instructions. There are several problems with "static directional" navigation systems. First, they do nothing to help the driver follow the route. The driver must determine for herself when to apply each instruction. Instructions like "drive half a mile, then turn left onto Maple Street" are no use if the driver is unable to measure mileage or can not determine the name of the street. The urban street network contains many short connecting roads (access ramps) which are nameless. Finally, even a named street might be missing its sign. In addition, the driver must keep track of which instruction is next. A second problem is that since the instructions must be specified in advance, there is little to be done if the driver does not follow the instructions, which might happen from error, or because the instructions are wrong, or simply ill-advised (as

Chapter 8

Future Developments

The Back Seat Driver works. It works well enough that one can imagine something very much like it being sold within a few years. There remain some areas for further research. Some of these involve only the Back Seat Driver, while others have to do with how a system like the Back Seat Driver would fit into the larger context of urban planning and public policy. The Back Seat Driver of the future will not simply be something installed in a car, rather it will be part of a network of information and services that includes your home and office, other drivers, and perhaps the local police agency.

This chapter discusses areas for further research. The topics are arranged roughly in order of increasing scale, ranging from the connection between the Back Seat Driver and other systems in the car to the connections with Federal law.

8.1 Integration with the car

The Back Seat Driver should be running on a computer embedded in the car, so that it can get more and better information about the state of the car and driver.

Appendix C

Communication with the car

The Back Seat Driver is a prototype of an in-car navigation system, but it was actually implemented on a large workstation computer[1]. This computer is too large to fit into the car, so instead I used cellular phones to carry data from the car to the computer, and voice from the computer to the driver. This chapter describes the actual experimental setup. It is of little theoretical interest, but may be of practical value to others attempting to send data through cellular phone links. in this area.

The workstation communicates with the driver and the onboard hardware through cellular phones, as shown in figure C-1.

The position sensor estimates vehicle position, heading, and velocity, and sends a data packet, once per second, through the modem to the workstation. The workstation sends characters to the Dectalk speech synthesizer, which in turn sends voice over a second phone to the driver.

[1] a Symbolics Lisp Machine

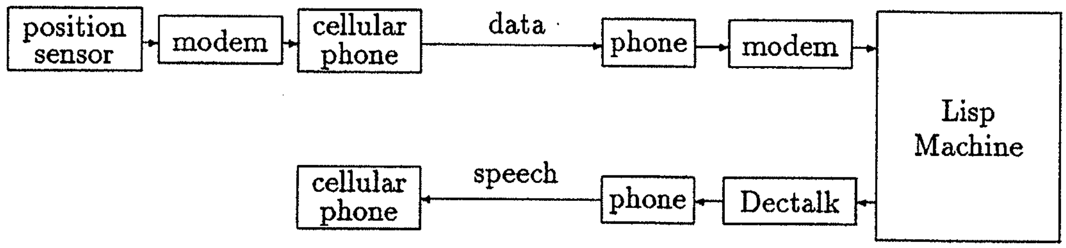

Figure C-1: Communications block diagram

C.0.2 Cellular phones are hostile for data transmission

Nearly everyone who has used a cellular phone knows how noisy they are. Cross talk is common. On several occasions I have heard one and even two other conversations at the same time. Noise bursts and signal loss make it hard to hear. A sufficiently bad noise burst can even cause the cellular system to terminate the call. The problems for data transmission are even worse[6]. By its very nature, cellular radio transmission is subject to multi-path interference, which causes periodic fades as the antenna moves in and out of anti-nodes. In addition to this fading, there is a complete loss of audio signal for as long as .9 seconds when the phone switches from one cell site to another (hand off).

My attempt to use an ordinary (land-line) modem from the car[2] was unsuccessful. Even at 300 baud the connection was too noisy to use. Worse, connections seldom lasted more than five minutes. In all cases, I set the "loss of carrier" register (S10) to its maximum value, 20 seconds. Loss of carrier signal alone can not explain why the connections dropped. The modems were capable of tolerating a complete loss of audio for up to twenty seconds.

[2]I used a Worldlink 1200 from Touchbase systems in the car, with a Morrison and Dempsey AB1 data adapter, and an NEC P9100 phone, boosted to 3 watts. At the base station I used both a Practical Peripherals 2400 and a Hayes Smartmodem 1200.

I had better results using an error correcting modem[3] made by the Spectrum Cellular Corporation. This modem uses a proprietary protocol (SPCL[60]) for error correction. The Spectrum product virtually eliminated noise, at the price of a lower data transmission rate. According to the protocol, the transmitting modem groups characters into packets that include error correction bytes. If only a few errors occur, the receiving modem repairs the data and acknowledges receipt. If there are many errors, the packet is retransmitted. If the sending modem has to retransmit too often it makes the packets smaller, on the assumption that at a smaller packet has a better chance of success. This is less efficient, since packets have a fixed overhead, the percent of the channel used by data decreases. When conditions improve the modem increases packet size again. In theory, the modem can transmit at 120 characters per second, but I estimate an average value closer to 30 characters per second. I made this estimate by recording the time required to receive the three characters of an odometer sequence. This sequence is transmitted once per second. Figure C-2 shows a histogram of durations for the three character sequence. The mean for this histogram is 94 milliseconds, which is 31 milliseconds

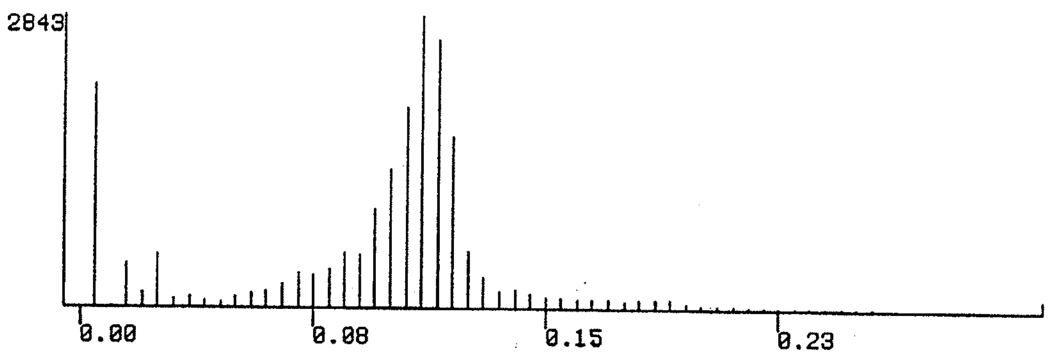

Figure C-2: Histogram of durations of odometer sequence

per character, or 32 characters per second. Tests by Fontana[24] found better results, between 75 to 80 characters per second.

[3]The "Bridge"

Even with the cellular modem, calls are sometimes dropped. Figure C-3 shows the probability of a call being dropped plotted against time. The measure of probability is obtained by comparing the number of calls dropped at or before time t with the number of calls that lasted at least that long. The call durations are usually long enough for a successful trip with the Back Seat Driver. Voice calls are dropped at about the same rate as data calls.

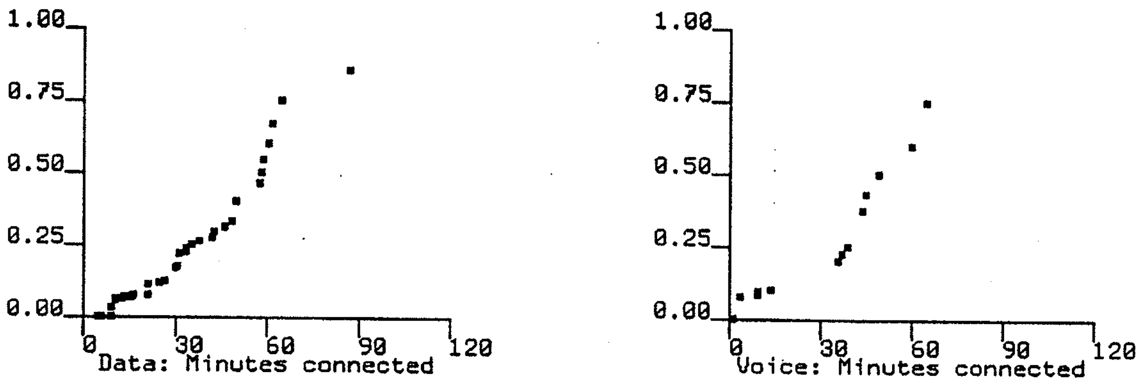

Figure C-3: Probability of cellular call termination increases with time

C.0.3 Retransmission introduces latency

The protocol used by the Spectrum modem acknowledges all data transmitted. If the acknowledgment is not received, it retransmits the data until acknowledged. Under adverse conditions, this can result in an arbitrarily long delay. This is a problem when real-time data is transmitted. Observation of the Back Seat Driver shows that sometimes the system will "freeze" for from one to ten seconds. During this time, the car of course continues to move. If these freezes occur near decision points, the driver may go past the intersection without being told what to do. At

20 miles per hour a car travels nearly 45 meters in five seconds. Figure C-4 shows a closeup histogram of the average arrival rate of odometer packets. The navigation system in the car sends a packet once every second. Most packets arrive within a second, but a few are delayed, some by up to ten seconds. (These delays may also arise from delays at the workstation. Lisp Machines are not noted for real-time response.)

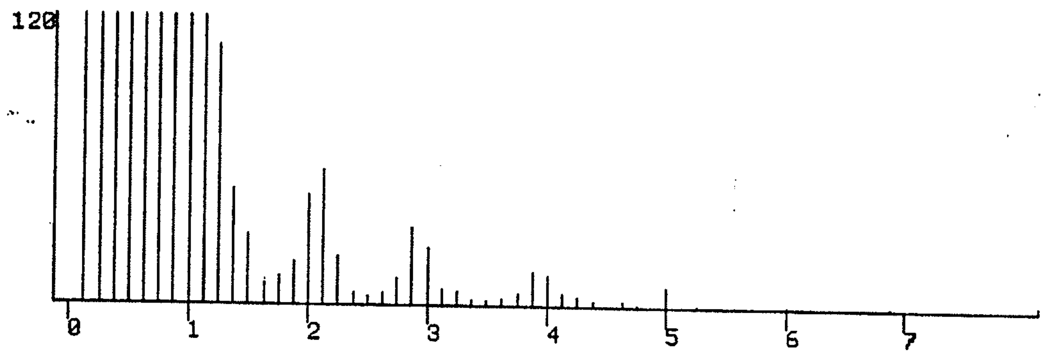

Figure C-4: Histogram of inter-arrival times of packets

It would be better to have a protocol which guarantees to deliver data intact and free of errors, if it delivers it at all, but does not guarantee to deliver the data. Real time data is only valuable in real time, and time spent retransmitting old data is taken away from never, more valuable data. Such a protocol modification is feasible for the Spectrum product (personal communication), and might be required for future work.

EXHIBIT 3

5177685

SERIAL NUMBER	FILING DATE	CLASS	SUBCLASS	GROUP ART UNIT	EXAMINER
07/569,274	08/09/90	364	443 449	2304	Pipala

JAMES R. DAVIS, NORTH CAMBRIDGE, MA; CHRISTOPHER M. SCHMANDT, MILTON, MA.

CONTINUING DATA*******************
VERIFIED

NONE

FOREIGN/PCT APPLICATIONS**********
VERIFIED

NONE

VERIFICATE
MAR 15 1994
OF CORRECTION

FOREIGN FILING LICENSE GRANTED 09/22/90

Foreign priority claimed / 35 USC 119 conditions met	AS FILED	STATE OR COUNTRY	SHEETS DRWGS	TOTAL CLAIMS	INDEP CLAIMS	FILING FEE RECEIVED	ATTORNEY'S DOCKET NO.
☐ yes ☐ no	→	MA	2	58	1	$ [illegible]	[illegible]

FISH & RICHARDSON
... STEWART
...
... STREET
BOSTON, MA 02109

AUTOMOBILE NAVIGATION SYSTEM Using Real Time Spoken Driving Instructions

U.S. DEPT. of COMM.- Pat. & TM Office-PTO-436L

PARTS OF APPLICATION FILED SEPARATELY

NOTICE OF ALLOWANCE MAILED	PREPARED FOR ISSUE 7-2-92		CLAIMS ALLOWED	
6/30/92	Edward Pipala Assistant Examiner	Docket Clerk	Total Claims 58	Print Claim 1

ISSUE FEE			DRAWING		
Amount Due $1130.00	Date Paid 9-25-92	PARSHOTAM S. LALL SUPERVISORY PATENT EXAMINER ART UNIT 234 Primary Examiner	Sheets Drwg. 3	Figs. Drwg. 5	Print Fig. 1

Label Area	ISSUE CLASSIFICATION		ISSUE BATCH NUMBER
	Class 364	Subclass 443	522

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[redacted]

Entered or Counted	CONTENTS	Received or Mailed
	1. Application papers.	
	2. [illegible]	8-28-90
	3. Fees + Decl.	09-10-90
	4. Prior Art	09-07-90
	5. Rej. 3 mos	[illegible]
	6. Ext. time 3 mos.	5-7-92
6-4	7. Amdt. A & Prior Art	5-7-92
[illegible]	8. Notice of Allow	6/30/92
	9. Formal Drwg (3 shts)	9/04/92
	10. PTO GRANT JAN 05 1993	
	11. Req. C of C R-322 + 323	4-28-93
	12. [illegible]	1-29-94
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PATENT APPLICATION SERIAL NO. 07 565274

U.S. DEPARTMENT OF COMMERCE
PATENT AND TRADEMARK OFFICE
FEE RECORD SHEET

070 LH 08/16/90 07565274 1 201 419.00 CK

PTO-1556
(5/87)

The examiner has rejected claims 1-58 under 35 U.S.C. 112, second paragraph, as being indefinite. Claim 1 has been amended to more particularly point out the connections and interactions between the different elements of the invention, as required by the examiner.

The examiner has rejected claims 1-58 under 35 U.S.C. 102(e) as being anticipated by the Ph.D. thesis of J.R. Davis. During a telephone conversation with the examiner, the examiner stated that the reason for the rejection was that the title page of the thesis bears a submission date of August 4, 1989, more than one year before the filing date of the present application. August 4 is the date that the thesis was signed, and not the date on which the thesis became available to the public. M.I.T. does not generally catalog and shelve theses until several months after the official date of submission. Enclosed is a copy of the title page of the M.I.T. library's copy of the thesis, which bears a date of February 27, 1990. Therefore, the thesis did not become available to the public more than a year before the filing date of the present application, and is therefore not 102 art with respect to the present application.

In response to the examiner's request, copies of references which were included in the Information Disclosure Statement filed with the application which the applicant considers pertinent to the present invention as claimed and which the applicant would like to be considered and made of record are enclosed and included on a new PTO-1449.

It is respectfully submitted that the claims are now in condition for allowance, and it is requested that a Notice of Allowance be issued.

Please charge any fees in connection with this response to our Deposit Account No. 08-1721.

Respectfully Submitted,

Sam Pasternack

Sam Pasternack, Esq.
Reg. No. 29,576

Choate, Hall & Stewart
Exchange Place
53 State Street
Boston, MA 02109
(617) 227-5020

May 5, 1992

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail in an envelope addressed to: Commissioner of Patents and Trademarks, Washington, D.C. 20231, on May 5, 1992

Sam Pasternack

EXHIBIT 4

TO BE FILED UNDER SEAL

PURSUANT TO MIT'S ASSENTED-TO MOTION TO FILE UNDER SEAL (DOCKET NO. 158)

EXHIBIT 5

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF MASSACHUSETTS

MASSACHUSETTS INSTITUTE OF TECHNOLOGY, **Plaintiff,** **v.** **HARMAN INTERNATIONAL INDUSTRIES, INCORPORATED,** **Defendant.**	**Case No: 05-10990 DPW** **Hon. Douglas P. Woodlock**

MIT'S AMENDED RESPONSE TO HARMAN'S FIRST SET OF <u>INTERROGATORIES (AMENDING RESPONSES TO INTERROGATORY NOS. 6-7)</u>

Pursuant to Rules 26 and 33 of the Federal Rules of Civil Procedure, Plaintiff, Massachusetts Institute of Technology ("MIT") submits the following responses and objections to Harman International Industries, Incorporated's ("Harman's") First Set of Interrogatories (Nos. 1-7) [counted with subparts as Nos. 1-29] (the "Interrogatories"):

<u>GENERAL OBJECTIONS</u>

The following general statements and objections are incorporated into each of MIT's responses, as set forth there in full, even if not repeated therein:

1. MIT objects to the Interrogatories to the extent they refer to an Appendix A to Harman's First Set of Document Requests to MIT, which does not exist.

2. MIT objects to Harman's method of counting, but under Harman's counting method, Harman has served twenty-nine (29) interrogatories, and thus has exceeded the twenty-five (25) permitted by Rule 33 of the Federal Rules of Civil Procedure. Upon mutual agreement of

information provided regardless of whether such information is newly discovered or currently in existence. MIT may, in the future, obtain or locate additional information responsive to these Interrogatories. Further, a complete response to certain Interrogatories depends in part upon information to be adduced from Harman or third parties during discovery, which is in its early stages. MIT, therefore, reserves its right, at any time, to revise, amend, correct, supplement, modify, or clarify its responses, on a timely basis, in accordance with Federal Rules of Civil Procedure 26 and 33.

SPECIFIC OBJECTIONS AND RESPONSES

INTERROGATORY NO. 6

For each asserted claim of the Patent-In-Suit, state when a prototype that embodied each alleged invention of the patents in suit was first made and when and to whom such prototype was first disclosed; explain in detail the circumstances surrounding the prototype (including without limitation its making and disclosure); and identify all persons with knowledge of these events.

RESPONSE TO INTERROGATORY NO. 6 (ONCE AMENDED)

MIT objects to this interrogatory on the grounds that it is premature, because the response is dependent on contentions regarding claim construction, which both by agreement and by order of the Court, are not yet due in this matter. MIT further objects to this Interrogatory as premature to the extent it purports to request MIT to construe language of the written description of the '685 patent synonymously with language appearing in the claims of the '685 patent. MIT further objects to this interrogatory, because MIT has not yet completed its factual and legal analysis with regard to infringement and claim construction, and thus contention interrogatories regarding the interpretation of each claim are premature at this stage of the litigation. MIT further objects to this interrogatory because it seeks information protected by the attorney-client

privilege, work product doctrine, and/or other applicable privileges. MIT further objects to this interrogatory on the grounds that it is vague and ambiguous. Specifically, it fails to define the terms "prototype" and "alleged invention." MIT further objects to this interrogatory, because, when all subparts are counted according to Rule 33 of the Federal Rules of Civil Procedure, Harman has exceeded its limit of 25 interrogatories.

Subject to, and without waiving, the foregoing general and specific objections, MIT states that, to the best of its knowledge, there were at least three test units of the "Back Seat Driver" system. Initially, the inventors created a first test unit that required a person riding in the back seat of an automobile to input data regarding navigation of the automobile. The system utilized a remotely-stationed Symbolics-Lisp® brand computer. The system involved transferring data to and from the automobile over two lines of a cellular telecommunications system: one line for speech data and one line for other data. The speech generator in the first test unit was implemented using a Dectalk® brand speech synthesizer.

In a second test unit of the system, which was created prior to the time that Dr. Davis was awarded his Ph.D., the main computing apparatus was also a remotely-stationed Symbolics-Lisp® brand computer. This test unit included a location system that tracked the position of the automobile using the location system's own map database. The location system was supplied by Nippon Electronics Company ("NEC"). The speech generator in the second system was also implemented using a Dectalk® brand speech synthesizer, and, similar to the first test unit, the second system utilized two lines of a cellular telecommunications system to transfer data.

A third test unit of the system was created after MIT awarded Dr. Davis his Ph.D. in September 1989 and prior to the filing of U.S. Patent Application No. 565,274 on August 9,

1990. The third system included a Sun® brand Sparcstation® computer mounted in the trunk of an automobile. The third system also used the NEC location equipment.

All three test units were created for experimentation, research and development purposes in conjunction with research sponsored by NEC. The persons with information regarding the development of the device and any associated disclosure are the inventors, Dr. Davis and Prof. Schmandt.

At this time, MIT is unable to determine whether each or any of these test units embody one or more of the asserted claims in this action, because the Court has not yet construed the claims.

INTERROGATORY NO. 7

Identify each "working prototype of the Back Seat Driver" (*see, e.g.,* col. 3, lns. 4-5), including without limitation the date(s) upon which each such prototype was created , "implemented" (*see, e.g.,* col. 3, In. 5), demonstrated, displayed, shown, tested, and/or reduced to practice and each person involved in any such act, and describe how the "map database for the Back Seat Driver in [each] working prototype" (*see, e.g.,* col. 4, Ins. 13-15) represented "physical connectivity" and "legal connectivity" as those terms are used in the Patent-In-Suit (*see, e.g.,* col. 4, In. 61 - col. 5, In. 14).

RESPONSE TO INTERROGATORY NO. 7 (ONCE AMENDED)

MIT objects to this interrogatory on the grounds that it is premature, because the response is dependent on contentions regarding claim construction, which both by agreement and by order of the Court, are not yet due in this matter. MIT further objects to this Interrogatory as premature to the extent it purports to request MIT to construe language of the written description

of the '685 patent synonymously with language appearing in the claims of the '685 patent. MIT further objects to this interrogatory, because MIT has not yet completed its factual and legal analysis with regard to infringement and claim construction, and thus contention interrogatories regarding the interpretation of each claim are premature at this stage of the litigation. MIT further objects to this interrogatory because it seeks information protected by the attorney-client privilege, work product doctrine, and/or other applicable privileges. MIT further objects to this interrogatory on the grounds that it is vague and ambiguous. Specifically, it refers to terms from the specification and claims that have not yet been construed by the Court. MIT further objects to this interrogatory, because, when all subparts are counted according to Rule 33 of the Federal Rules of Civil Procedure, Harman has exceeded its limit of 25 interrogatories.

Subject to, and without waiving, the foregoing general and specific objections, MIT states that, to the best of its knowledge, there were at least three test units of the "Back Seat Driver" system. Initially, the inventors created a first test unit that required a person riding in the back seat of an automobile to input data regarding navigation of the automobile. The system utilized a remotely-stationed Symbolics-Lisp® brand computer. The system involved transferring data to and from the automobile over two lines of a cellular telecommunications system: one line for speech data and one line for other data. The speech generator in the first test unit was implemented using a Dectalk® brand speech synthesizer.

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At this time, MIT is unable to determine whether each or any of these test units embody one or more of the asserted claims in this action, because the Court has not yet construed the claims.

Dated: January 9, 2006

Respectfully submitted,

Massachusetts Institute of Technology,

By its Attorneys,

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CERTIFICATION

I, the undersigned, have reviewed MIT's Amended Responses to Harman's First Set of Interrogatories (Nos. 6-7). The responses set forth herein, subject to inadvertent or undiscovered errors or omissions, are based on and therefore necessarily limited by the records and information still in existence, presently recollected, thus far discovered in the course of preparation of the responses, and currently available to MIT. Consequently, MIT reserves the right to make any changes in or additions to any of these responses if it appears at any time that errors or omissions have been made therein or that more accurate or complete information has become available. Subject to the limitations set forth herein, said responses are true to the best of my present knowledge, information and belief.

I hereby certify under penalty of perjury that the foregoing is true and correct.

Executed on this 10th day of January, 2006.

John H. Turner Jr

John H. Turner, Jr.
Associate Director, Technology Licensing Office
On behalf of Massachusetts Institute of Technology

CERTIFICATE OF SERVICE

I HEREBY CERTIFY that on January 9, 2006, I caused a true and correct copy of the foregoing document to be served on the following counsel of record via email:

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By: Kimberly A. Mottley
Kimberly A. Mottley

EXHIBIT 6

TO BE FILED UNDER SEAL

PURSUANT TO MIT'S ASSENTED-TO MOTION TO FILE UNDER SEAL (DOCKET NO. 158)

EXHIBIT 7

TO BE FILED UNDER SEAL

PURSUANT TO MIT'S ASSENTED-TO MOTION TO FILE UNDER SEAL (DOCKET NO. 158)

EXHIBIT 8

VOLUME 1

PAGES 1 - 301

EXHIBITS D32 - D44

IN THE UNITED STATES DISTRICT COURT

FOR THE DISTRICT OF MASSACHUSETTS

No. 05-10990 DPW

- -

MASSACHUSETTS INSTITUTE OF TECHNOLOGY,

Plaintiffs

vs.

HARMAN INTERNATIONAL INDUSTRIES, INCORPORATED,

Defendants

- -

VIDEOTAPED DEPOSITION OF CHRISTOPHER M. SCHMANDT

Wednesday, February 8, 2006 9:38 a.m

Proskauer Rose LLP

One International Place, Boston, MA 02111

Reporter: Janet M. Konarski, RMR, CRR

LegaLink Boston

320 Congress Street, Boston, MA 02110

(617)542-0039

THE VIDEOGRAPHER: Here begins Videotape No. 1 in the deposition of Chris Schmandt in the matter of Massachusetts Institute of Technology v. Harman International Industries, Incorporated in the United States District Court for the District of Massachusetts, Case No. 05-10990DPW. Today's date is February 8, 2006. The time on the video monitor is 9:38 a.m.

The video operator today is Jason Lachapelle, a notary public, contracted by LegaLink Boston. This deposition is taking place at One International Place, Boston, Massachusetts, and was noticed by Kirkland & Ellis for the defense.

Counsel, please voice identify yourself and state whom you represent.

MR. BAUER: Steven Bauer from Proskauer Rose, representing MIT and the witness.

MS. MOTTLEY: Kimberley Mottley from Proskauer Rose, representing MIT and the witness.

MR. LEAVELL: Craig Leavell from Kirkland and Ellis, representing Harman.

MR. HART: Robert Hart representing Harman International.

THE VIDEOGRAPHER: The court reporter

today is Janet Konarski. Would the reporter please swear in the witness.

CHRISTOPHER M. SCHMANDT,

having been duly sworn, after presenting identification in the form of a driver's license, deposes and says as follows:

DIRECT EXAMINATION

BY MR. LEAVELL:

Q. Good morning, sir.

A. Good morning.

Q. We've introduced each other, but for the record, my name is Craig Leavell, and I'll be taking your deposition today. It's important that you understand each question that I ask of you. So, if there is any time that you don't understand a question or any portion of a question that I ask you, will you let me know, so that I can rephrase or try to fix the question?

A. I'll do my best.

Q. It's also important that you hear my questions. If there is a question I ask that you don't hear, will you let me know, so that I can repeat it?

A. Again, I'll do my best.

Q. If at any time today you realize that an

progress at that point. This was a proposal to do Back Seat Driver. Portions of Back Seat Driver, portions of the software that we used in Back Seat Driver had been previously completed.

Q. With Mr. Davis's help, correct?

A. Look on Page 3, "Prior Experience," there is a paragraph, there is a section entitled "Direction Assistance." Direction Assistance was Jim Davis's program and has been published under his name. It also references Grunt, which is a program that I had written and had been published under my name. Up to that point, I had, our work on these two projects was separate.

Q. Up until June 15 of 1988, Mr. Davis's work and your work were separate? Is that what you said?

A. No. He was a student of mine, but I had not, I had not been very involved in the Direction Assistance project. This was a proposal for work that he and I were going to do together, let's say.

Q. Is there anything that you contributed to the Direction Assistance project technically?

MR. BAUER: Objection. Vague.

A. Certainly various aspects of the discourse generation, yes.

Q. What does it mean for the map database to have a minimum accuracy of 10 meters?

A. That means that where the map database says something is located on the surface of the earth that the actual location is within 10 meters of the said location.

Q. What was the map accuracy of the actual system built by MIT?

A. I don't recall. It's probably documented in Jim's thesis.

Q. Did the map database that was actually used on the Back Seat Driver built by MIT start out as a dime file?

A. If you want a -- I think in order to answer that question I would have to refer to the documents.

Q. What documents?

A. Jim Davis's thesis.

Q. Okay. Well, we'll get to that. What type of car was the Back Seat Driver installed in?

A. Acura Legend.

Q. Where was that -- was that car ever parked out in the open with the system in it, or was there an effort made to keep it more secure than that?

A. It was parked in an MIT garage, which had card access.

Q. But, the system was left in their overnight? It wasn't removed every time the car was parked?

A. There were several versions of the system. In one version of the system, the system, the computer portion of the system was in a machine room at the MIT Media Lab, and it never left that room.

Q. Right.

A. And the other portion -- the other version, the computer portion of the system was in the trunk of the car and was firmly attached by means of anti-vibration platform to the trunk of the car.

Q. When was the switch made from the computer being located in the Media Lab to being located in the trunk of the car?

A. I can't give you an exact date, but it was sometime after the time that Jim Davis graduated.

Q. When did he graduate?

A. He graduated in -- at the end of the summer. I don't know whether the date is August or September of 1989. At that point, we requested and received another year's funding from NEC, the primary

A. Yes. May -- yes.
Q. Do you still have any Back Seat Driver systems?
A. There was only one --
Q. Do you still --
A. -- that was built.
Q. Do you still have it?
A. No.
Q. What happened to it?
A. NEC repurchased the vehicle from us and took the equipment with it.
Q. When did they do that?
A. At the end of the research period.
Q. Which was when?
A. It would have been -- I can't tell you the exact date, because I'm not sure when it ended, because we took a no cost extension, probably sometime in 1992.
Q. So, people that are familiar with your work on the Back Seat Driver system have said, Wow, that's a neat system, how did they see the system? It was before NEC took it back in '92?
A. There were people, who had ridden in it.
Q. Since '92?
A. Once we -- sorry?

Q. Since 1992?
A. No. Obviously, once they had it, then they couldn't ride in it.
Q. Right. But, since 1992 --
A. The best experience, the best experience --
MR. BAUER: Wait, wait, wait. He's asking a new question, so --
Q. Since 1992, has anybody ever come up to you and said, Wow, that is really impressive work?
A. Yes.
Q. Who?
A. I can't tell you.
Q. You can't or you don't remember or you won't? Which is it?
MR. BAUER: That's argumentative. It's a fair question in terms of how you phrased it, but the way he phrased the question so far that was a very argumentative question.
MR. LEAVELL: I don't mean to be argumentative.
A. I don't remember who in particular has seen it. I have shown that video to many, many people.
Q. What video?

CORRECTIONS TO DEPOSITION TRANSCRIPT
OF CHRISTOPHER M. SCHMANDT
February 8, 2006

MASSACHUSETTS INSTITUTE OF TECHNOLOGY V. HARMAN INTERNATIONAL INDUSTRIES INC., C.A. NO. 05-10990-DPW

Page	Line	Change/Correction	Reason
Global	Global	Change "Trobough" to "Trobaugh"	Transcription error
Global	Global	Change "realtime" to "real time"	Transcription error
Global	Global	Change "dime" to "DIME"	Transcription error
10	15	Change "I was" to "They were"	Clarification
51	2	Change "media lab" to "Media Lab"	Transcription error
57	17	Change "you o know" to "you know"	Transcription error
68	20	Change "Stephen Marte" to "Stefan Marti"	Transcription error
69	8	Change "sense" to "since"	Transcription error
78	23	Change "invention" to "information"	Clarification
79	8	Change "invention" to "information"	Clarification
89	4-5	Change "committee on the use of humans in experimental subjects" to "Committee on the Use of Humans as Experimental Subjects"	Transcription error
96	3	Change "Rittbueler" to "Rittmueller"	Transcription error
128	24	Change "now" to "know"	Transcription error
130	8	Change "we're" to "were"	Transcription error
130	9	Change "we're" to "were"	Transcription error
131	21	Change "MS. MOTTLEY" to "MR. HART"	Transcription error
158	1	Change "tie-down" to "tied-down"	Transcription error
182	16	Change "tit" to "it"	Transcription error
186	13	Change "List" to "Lisp"	Transcription error
186	13	Change "Spark" to "Sparc"	Transcription error
202	15	Change "68,000" to "68000"	Transcription error
203	4-6	Change "Yes. 'The computing apparatus appears to be a pair of microprocessors, at least one of which is a Motorola 68,000.'" to "Yes. The computing apparatus appears to be 'a pair of microprocessors, at least one of which is a Motorola 68000.'"	Transcription error
205	8	Change "It's a drawing. So, one of" to "It's a drawing. BY MR. LEAVELL: Q. So, one of"	Transcription error
213	20	Change "their" to "the"	Transcription error
216	15	Change "lane be" to "lane may be"	Transcription error
234	5	Change "list" to "Lisp"	Transcription error
238	11	Change "an affeer of" to "anaphora"	Transcription error
251	6	Change "media library" to "Media Lab Library"	Transcription error

**CORRECTIONS TO DEPOSITION TRANSCRIPT
OF CHRISTOPHER M. SCHMANDT
February 8, 2006**

MASSACHUSETTS INSTITUTE OF TECHNOLOGY V. HARMAN INTERNATIONAL INDUSTRIES INC., C.A. NO. 05-10990-DPW

Page	Line	Change/Correction	Reason
259	16	Change "degenerative rates" to "degenerates"	Transcription error
278	17	Change "hardware man" to "Harman"	Transcription error
280	12-13	Change "Before Voice Assisted Automobile Navigation" to "Back Seat Driver: voice assisted automobile navigation"	Transcription error
285	10	Change "spark station" to "Sparc Station"	Transcription error
286	4	Change "tiger" to "TIGER"	Transcription error
287	9	Change "deertation" to "dissertation"	Transcription error

I have read the foregoing transcript of my deposition and except for the corrections and changes noted above, I hereby subscribe to the transcript as an accurate reflection of the statements made by me.

Christopher M. Schmandt

EXHIBIT 9

TO BE FILED UNDER SEAL

PURSUANT TO MIT'S ASSENTED-TO MOTION TO FILE UNDER SEAL (DOCKET NO. 158)

EXHIBIT 10

VOLUME: I

PAGES: 1-248

EXHIBITS: 66-89

UNITED STATES DISTRICT COURT

DISTRICT OF MASSACHUSETTS

- - - - - - - - - - - - - - - - - - x

MASSACHUSETTS INSTITUTE OF TECHNOLOGY,

Plaintiff,

v. Civil Action No. 05-10990-DPW

HARMAN INTERNATIONAL INDUSTRIES INCORPORATED,

Defendant.

- - - - - - - - - - - - - - - - - - x

CONFIDENTIAL

VIDEOTAPED DEPOSITION of JAMES R. DAVIS

February 16, 2006

9:17 a.m.

Proskauer Rose

One International Place

Boston, Massachusetts

Reporter: Michael D. O'Connor, RPR

P R O C E E D I N G S

VIDEOGRAPHER: Here begins videotape number one in the deposition of James R. Davis in the matter of Massachusetts Institute of Technology versus Harman International Industries, in U.S. District Court of Massachusetts, Case No. 05-1099-DPW.

Today's date is February 16, 2006. The time on the video monitor is 9:17 a.m. The video operator today is Richard Mendes, contracted by LegaLink, Boston, Massachusetts. This video deposition is taking place at Proskauer Rose, One International Place, Boston, Massachusetts.

Counsel, please voice identify yourselves and state whom you represent.

MR. BAUER: Steven Bauer from Proskauer Rose representing M.I.T. and the witness.

MR. LEAVELL: Craig Leavell from Kirkland & Ellis representing the Defendant Harman.

VIDEOGRAPHER: The court reporter today is Michael O'Connor of LegaLink Boston. Would the reporter please swear in the witness.

JAMES R. DAVIS

having been satisfactorily identified by the production of his driver's license, and duly sworn by the Notary Public, was examined and testified as follows:

VIDEOGRAPHER: Please begin.

DIRECT EXAMINATION

BY MR. LEAVELL:

Q. Good morning, sir.

A. Good morning.

Q. I'm going to hand you a copy of what's been previously marked as Defendant's Exhibit 32, a copy of U.S. Patent No. 5,177,685. If I refer to that as the '685 patent or your patent, will you understand that that's what I'm referring to today?

A. I will.

Q. You are the James R. Davis that's listed as an inventor on the face of the '685 patent?

A. I am.

Q. Mr. Davis, who do you currently work for?

A. The Ontario Principals Council of Toronto,

A. Yes.

Q. Which one?

A. The Toronto, Canada address is the correct one. That's Exhibit 68. It is the more recent of the two.

Q. If you can look at Exhibit 68, on the second page, from September of 1989 through September of 1990, it says on the third line down, "I also continued development on my thesis project, 'The Back Seat Driver'." Do you see that?

A. I do.

Q. Do you recall what you did in terms of development of "The Back Seat Driver" from September of 1989 to September of 1990?

A. Yes.

Q. What did you do?

A. Among other things, we built another prototype of the system where the computer was installed in the car instead of using the cellular telephone apparatus to communicate to a computer that remains stationary.

Q. So prior to September of 1989, you had not built that in-car system?

A. I do not recall the precise date where we

former race car driver. They might have been kidding me to make fun of me after my program crashed.

Q. What was the purpose of demonstrating "The Back Seat Driver" to a group from General Motors?

A. Would you rephrase that.

Q. Was "The Back Seat Driver" a working device at the time you showed it to General Motors?

A. Yes.

Q. Were you showing it to General Motors for any experimentation purposes?

MR. BAUER: Objection. Vague. Calls for a legal conclusion.

A. "The Back Seat Driver" was always a research prototype, and I attempted to learn things from every experience I had of "The Back Seat Driver." Certainly in this case I learned something important about U-turns that I might never have learned.

Q. Why do you say certainly you learned that; based on what you've read here in Exhibit 71?

A. My mistake. I should not have said certainly, since one might have learned it in other ways. But in this particular case, because the

driver made a maneuver I hadn't previously imagined anyone would do, I learned that my program would have to account for such things in the future.

Q. Do you actually recall that or is that answer you just gave me based on what you've read here in Exhibit 71?

A. I have a vague recollection of the neighborhood in Cambridge where this occurred. So I do have an independent recollection of the U-turn.

Q. How many people were in the car at the time of the U-turn?

A. At least three, and fewer than seven.

Q. Do you specifically recall that or are you just basing that because of what's written here on Exhibit 71?

A. Well, I'm basing that on the use of the plural, which indicates the word at least two from General Motors and myself.

Q. The use of the plural in the document?

A. The use of the plural in the document, that's correct.

Q. So you don't have any specific recollection as you sit here today of there being three people or four people or five people in that car, do you?

Q. Do you recall any communications with Ms. Stuck at all?

A. No.

Q. Do you recall receiving any other requests from anybody about information on "The Back Seat Driver" project prior to August of 1990? Let me rephrase that.

A. Thank you.

Q. Prior to August of 1989, did you ever receive any additional requests from anyone, aside from Ms. Stuck, for information about "The Back Seat Driver" project?

A. You mean by that people outside of M.I.T.?

Q. Let's start there. Correct.

A. No.

VIDEOGRAPHER: This marks the end of tape number one. Going off the record at 11:23.

(Recess)

VIDEOGRAPHER: This marks the beginning of tape number two. We are back on the record at 1130.

BY MR. LEAVELL:

Q. Mr. Davis, we are still looking at Exhibit 79. The second e-mail on Page 1 from Ms. Stuck to you is dated a little under an hour later, and it

says, "I think I can wait a couple weeks to see your thesis. I'd be interested in seeing your thesis proposal. That could tide me over until I see the real thing. Would you mind sending me a copy? E-mail would be fine."

Did you send Ms. Stuck a copy of your thesis proposal in or around May of 1989?

A. I don't recall.

Q. Did you send an e-mail to Ms. Stuck between the two e-mails that are shown here explaining to her that your thesis would be done in a couple of weeks?

A. It's a fair surmise from the text to assume that I did so. I do not recall corresponding with Ms. Stuck, and I can only go on these e-mails here. I think it would be fair to say that I have no reason to doubt, given the e-mails here, that I did reply to her first e-mail.

Q. Is there any reason to doubt that you forwarded her a copy of your thesis proposal in or around May of 1989?

A. There's no evidence here one way or the other.

Q. Does that sound like something you would

have done back in May of 1989?

MR. BAUER: Objection. Speculation.

A. So one would speculate, I do speculate, that given such a request, I might have sent her the thesis proposal, which would describe what problem I was attempting to solve and why it was a novel solution, a novel problem, a problem worthy of attention. But it would not, of course, describe the actual solutions or conclusions of the work, only what's the problem.

Q. When did you prepare the thesis proposal?

A. I don't recall.

Q. Did you provide a copy of it to Mr. Schmandt or M.I.T. when it was done?

A. Yes.

Q. When was the last time you saw a copy of the thesis proposal?

A. I don't recall.

Q. Is there a place where the thesis proposals were stored at M.I.T. when they were submitted?

A. I do not know.

Q. Do you know where your thesis proposal was stored at M.I.T.?

A. I do not know. I do not know that they are

Q. This is another article that you and Mr. Schmandt published, correct?

A. Yes.

Q. When was Exhibit 81 published?

A. Just a moment, please. This appears to be from the vehicle navigation and information systems conference in September of 1989.

Q. Did you look to the front of your patent to get that date?

A. Yes.

Q. On the front of your patent there's an article or a conference dated June 6 through 9, 1989. Do you see that?

A. I'm sorry, would you repeat that question?

Q. On the face of the '685 patent, the first under list of publications is a conference from June 6 to 9, 1989?

A. Yes.

Q. Did you present a paper at that conference?

A. I don't recall whether Chris presented the paper or I presented the paper.

Q. Do you recall going to that conference?

A. I don't recall going to the conference.

Q. Do you know whether Mr. Schmandt ever

demonstrated "The Back Seat Driver" of system at any of these conferences, like the one in June of '89?

A. I do not think it would have been possible for him to demonstrate the system, since to do that he would have to bring the car with him, and that wouldn't be easy to do.

Q. Well, a videotape was made of "The Back Seat Driver" system, correct?

A. I believe the video -- there was a videotape made. I believe it was made subsequent to September of '89.

Q. Why do you believe that?

A. I'm speculating now. I think it would be better if I saw the videotape.

Q. On the bottom of the front page of Exhibit 80, there's a date that says, "Manuscript received June 9, 1989." Do you see that?

A. I do.

Q. Do you have any reason to doubt that a manuscript for this article was supplied to the IEEE back in June of 1989?

A. I have no reason to doubt that.

Q. Is there any reason to believe that the IEEE was told that they had to keep that manuscript

think I did anything different than anyone else would have done. But that certainly includes not disclosing wildly to people who shouldn't see the thing, the work.

Nicholas would have been very angry with me if I, for instance, scheduled an interview on TV and said, here is what I'm doing, and gave away everything. That would have made it harder for him to continue to get sponsors for the lab.

That obligation really applies to everyone at the lab, and it's something that one understands, because it's part of the culture. Does that respond to your question? If not, try to rephrase it.

Q. It's a response. Is there anything that you can point me to, any affirmative step that you took, to preserve the confidentiality or secrecy of the work that you were doing on "The Back Seat Driver" project?

MR. BAUER: Mr. Leavell, does that include things he didn't do? So when he didn't publish, would you include that within your answer.

Q. Let me be more specific. When you were driving around Boston and Cambridge in "The Back Seat Driver," did you take any steps to protect the

secrecy or confidentiality of the system?

A. No one looking at the car from outside would have any reason to suspect that there was anything unusual in the car. It's certainly not necessary to, you know, disguise the car.

You can't tell from looking what's going on. So it was not necessary to do the trials only at night or something if that's what you're getting at.

Q. I'm getting at anything. Is there anything that you did to ensure people weren't observing or listening or watching what you were doing?

A. It wasn't necessary.

Q. So you didn't do it?

MR. BAUER: Objection.

A. No.

MR. BAUER: Good time for lunch? It's 12:30.

MR. LEAVELL: Let me go a minute or two more.

Q. Mr. Davis, I want to go back to the "Direction Assistance" program that was on display at the Boston museum. What physical components made up that exhibit in the museum? In other words, was

work, but before you signed your thesis on August 4th of 1989?

A. Sorry, would you please repeat that.

Q. Did you continue to use the working "Back Seat Driver" with other people around the Boston area between June of '89, which you say is when you knew it would work, and August of '89, when you signed your thesis paper?

A. First of all, I think what I testified is that by June of '89 I was confident that the system would work. The date that that confidence began to appear, I'm not sure what the earliest date of confidence was. Now I've forgotten the second part of your question, so I must ask you to repeat it.

Q. Did you continue to have people use "The Back Seat Driver" to navigate the Boston area after June of '89, but before you signed your thesis in August of '89, that two- or three-month period?

A. I do not recall the period when the experimentation began and the period when the experimentation ended. I do not recall what dates people drove in the car, so I cannot answer your question.

Q. Do you recall whether you personally were

contributed with a navigation system or symbolics Lisp machine. Is the distinction clear to you?

Q. Yes. On the next page of your acknowledgments, you identify four people who you thank for careful editing, beginning with Anna Korteweg, correct?

A. Yes. K-o-r-t-e-w-e-g.

Q. Now, Ms. Korteweg was your girlfriend or fiance at the time; is that correct?

A. That's correct.

Q. Is she your wife now?

A. We are still married.

Q. How long did she spend editing your thesis?

A. I have no clear recollection.

Q. How long before you signed the thesis did she see a copy of it?

A. I don't know.

Q. Was she a student at M.I.T. at the time?

A. No.

Q. Do you think she saw it more than a couple weeks before you signed it?

A. That's speculative, but it's likely.

Q. Did you ever give her a ride in "The Back Seat Driver" car?

A. I think so. I'm speculating, but it's impossible to believe that I didn't give her a ride.

Q. Prior to --

A. Actually, did she have a driver's license? Scratch that. I'm not sure that she ever drove the car.

Q. But she could have ridden in it?

A. Yes.

Q. Did she ride in it before you signed your thesis paper?

A. I don't recall.

Q. Who is Mr. Bender?

A. Walter Bender is another principal research scientist at the media lab. He would be roughly a peer to Chris Schmandt at that time.

Q. What about Mr. Drescher?

A. Gary Drescher is one of my very good friends from my undergraduate days and continues to be a friend to this day. I did him the favor of reading his thesis and he did me the favor of reading mine.

Q. Was he affiliated with M.I.T. during 1989?

A. I'm not sure if he was affiliated with M.I.T. in 1989.

could just take a couple of minutes and let me know if you can figure out what that stack is?

A. This is source code for some version of "The Back Seat Driver," and the date -- we don't know what version of it yet, and it clearly includes at least some software which was not directly part of "The Back Seat Driver," but was used for calibrating or testing "The Back Seat Driver."

Q. Did you write all the code for "The Back Seat Driver"?

A. I think that there are a few very small pieces that were contributed by other people. This would below-level routines for things like reading a weather map. So with those very small exceptions, yes, I wrote it all.

Q. Did Mr. Schmandt write any of it?

A. No.

Q. Were you able to incorporate any of the software that you wrote for the "Direction Assistance" program into the "Back Seat Driver" program?

A. I think so.

Q. How much of the "Direction Assistance" code got carried over and used in "The Back Seat Driver"

Boston Computer Museum, did your answers apply to the entire time that they were on display at the Boston Computer Museum or were they specific to any particular portion of time?

A. One more time could you just say that?

Q. Let me just clear this up. At the time the "Direction Assistance" display was installed in the Boston Computer Museum, did it have a discourse generator?

MR. BAUER: Objection. Undefined term. By what definition, Mr. Leavell?

Q. You can answer, sir.

A. The "Direction Assistance" program produces one kind of text. It doesn't produce real time text. It has a discourse generator, and it is a different discourse generator than "The Back Seat Driver."

Q. But did it have a discourse generator when it was first installed in the computer museum?

MR. BAUER: Objection. An undefined term.

A. There are two kinds of discourse generators we are talking about here.

Q. Understood.

A. I think you could -- from the standpoint of

discourse generator as I intended it in '685, no, it didn't have a discourse generator.

Q. Why not?

A. Because it wasn't doing real time discourse. This was a different kind of discourse.

Q. So now the claim one in order to have a discourse generator that falls within the scope of claim one has to be real time?

MR. BAUER: Objection. You're asking for a legal definition.

Q. Let me ask you this. Did the discourse generator that was present in the "Direction Assistance," did that ever change while it was installed in the Boston Computer Museum or did it stay the same?

MR. BAUER: Objection. Undefined term.

A. I'm pretty sure that once the museum exhibit went up -- I'm sorry, I can't recall whether I made any changes to the software after the exhibit was installed. I can't testify under oath that I didn't change it.

Q. What about the speech generator, the speech synthesizer, did that ever change after it was installed in the Boston Computer Museum?

from the museum. So if you'll just restate that with a different date, I can be more confident giving you a fully truthful answer.

Q. As it was installed in 1987, did it have that ability?

A. It had a taxonomy of turns, yes.

Q. And a taxonomy of intersection types?

A. Yes.

Q. And the discourse generated in relation to each intersection depended on its type?

A. That's correct.

Q. And as the "Direction Assistance" was installed in the Boston computer museum, the taxonomy of intersection types included continue, forced turn, U-turn, enter, exit, onto rotary, stay on rotary, exit rotary, fork, turn and stop, correct?

A. Are you reading from the "Direction Assistance" paper?

Q. I read that from claim 43 of the patent.

A. Okay. Without checking more carefully, it's difficult to say. The taxonomy did change over time as I learned better how turns ought to be described. So I could not testify under oath that

the taxonomy was identical in those two systems. In fact, I would be more inclined to testify that they changed.

Q. Is it reasonable to assume that the "Direction Assistance," as it was installed in the Boston Computer Museum in 1987, included the type of intersections disclosed in this paper on Pages 7 and 8, and continuing on to Page 9 as well, there's a list?

A. Could you repeat that, please?

Q. Sure. The paper says that Figure 8, and I'm reading from the bottom of Page 8, Figure 8 shows a taxonomy of acts. Does that mean that all of those acts were supported by the "Direction Assistance" program as it was installed in the Boston Computer Museum --

A. Yes.

Q. -- in 1987?

A. Yes, it does.

Q. Did the "Direction Assistance" program, as it was installed in the Boston Computer Museum in 1987, include a way for a driver or a user -- let's say a user -- to demand repetition of an instruction?

CORRECTIONS TO DEPOSITION TRANSCRIPT
OF JAMES R. DAVIS
February 16, 2006

MASSACHUSETTS INSTITUTE OF TECHNOLOGY V. HARMAN INTERNATIONAL INDUSTRIES INC., C.A. NO. 05-10990-DPW

Page	Line	Change/Correction	Reason
Global	Global	Change all "media lab" to "Media Lab"	Transcription error
Global	Global	Change "Mr. Pasternak" to "Mr. Pasternack"	Transcription error
29	13-14	Change "general motors" to "General Motors"	Transcription error
38	17	Change "satisfies" to "says"	Transcription error
43	23	Change "a known" to "unknown"	Transcription error
58	18	Change "reasoned" to "recent"	Transcription error
92	3	Change "genius" to "genus"	Transcription error
95	11	Change "ability" to "a built"	Transcription error
102	16	Change "censored" to "censured"	Transcription error
108	14	Change "THE WITNESS" to "MR. LEAVELL"	Transcription error
115	10	Change "sites" to "cites"	Transcription error
115	24	Change "now" to "no"	Transcription error
117	19	Change "rephrase" to "rephrasing"	Transcription error
121	22	Change "band" to "banned"	Transcription error
122	6	Change "band" to "banned"	Transcription error
141	19	Change "never I am imagined" to "never imagined"	Transcription error
143	23	Change "undersatnd" to "understand"	Transcription error
147	8	Change "an affera" to "anaphora"	Transcription error
156	15	Change "no" to "so"	Transcription error
181	9	Change "Pierre Humbert" to "Pierrehumbert"	Transcription error
198	16	Change "limb" to "him"	Transcription error
209	3	Change "sent" to "spent"	Transcription error
245	1	Change "was in the" to "wasn't"	Transcription error

I have read the foregoing transcript of my deposition and except for the corrections and changes noted above, I hereby subscribe to the transcript as an accurate reflection of the statements made by me.

James R. Davis

EXHIBIT 11

Volume: I

Pages : 1 - 140

Exhibits: 90 - 96

UNITED STATES DISTRICT COURT

DISTRICT OF MASSACHUSETTS

CIVIL ACTION NO. 05-10990-DPW

- -

MASSACHUSETTS INSTITUTE OF TECHNOLOGY,

Plaintiff,

v.

HARMAN INTERNATIONAL INDUSTRIES INCORPORATED,

Defendant.

- -

CONFIDENTIAL

VIDEOTAPED 30(b)(6)DEPOSITION OF M.I.T.

through CHRISTOPHER SCHMANDT

Friday, May 19, 2006, 2006, 9:40 a.m.

Proskauer Rose LLP

One International Place

Boston, Massachusetts

Reporter: Rosemary F. Grogan, CSR, RPR

LegaLink Boston, a Merrill Company

APPEARANCES:

Representing the Plaintiff:

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Boston, MA 02110
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kmottley@proskauer.com
BY: KIMBERLY A. MOTTLEY, ESQUIRE

Representing the Defendant:

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BY: CRAIG D. LEAVELL, ESQUIRE

Also present:

Jason Moschella, Videographer

09:34:12 THE VIDEOGRAPHER: This is the beginning of
09:39:44 videocassette No. 1 in the deposition of the
09:39:47 Massachusetts Institute of Technology by and
09:39:50 through Christopher Schmandt in the matter of
09:39:53 M.I.T., plaintiff, versus Harman International
09:39:56 Industries Incorporated, defendant, in the United
09:40:00 States District Court, District of Massachusetts,
09:40:04 Civil Action No. 05-10990-DPW.

09:40:11 Today is May 19, 2006. The time is 9:40 a.m.
09:40:15 My name is Jason Moschella. I'm a certified legal
09:40:20 video specialist and a notary public contracted by
09:40:23 LegaLink Boston. This deposition is taking place
09:40:26 today at the offices of Proskauer Rose LLP, One
09:40:30 International Place, Boston, Massachusetts and was
09:40:33 noticed by Kirkland & Ellis.

09:40:35 At this time counsel will please identify
09:40:38 yourselves and the court reporter will administer
09:40:40 the oath.

09:40:42 MR. LEAVELL: This is Craig Leavell from
09:40:42 Kirkland & Ellis on behalf of Harman International.

09:40:44 MS. MOTTLEY: This is Kimberly Mottley of
09:40:46 Proskauer Rose on behalf of M.I.T.

CHRISTOPHER SCHMANDT, having been satisfactorily identified by the production of a driver's license, and duly sworn by the Notary Public, was examined and testified as follows:

EXAMINATION BY MR. LEAVELL:

Q. Good morning, sir.
A. Good morning.
MR. LEAVELL: I'm going to ask the court reporter to mark the next exhibit as Exhibit 90.
(Exhibit 90 Marked for Identification)
BY MR. LEAVELL:
Q. Mr. Schmandt, have you seen a copy of Exhibit 90 prior to today, which is the Notice of Harman's First Rule 30(b)(6) Deposition of MIT, for the record?
A. Yes, I have.
Q. And you've had a chance to consult with counsel for M.I.T. about the scope of today's deposition; is that correct?
A. Yes, I have.
MS. MOTTLEY: I can represent for the record, Craig, that Mr. Schmandt is ready to testify on

09:50:31 Q. That it's reasonable to believe that somebody was driving on public Boston streets in July of 1989 using the Back Seat Driver System?

09:50:40 A. At least once, yes, it's likely.

09:50:44 Q. Is it also likely to believe -- or is it likely and reasonable to believe that somebody was driving the Back Seat Driver on a public road in the Boston area in the month of August of 1989?

09:50:59 A. I think it's highly unlikely.

09:51:02 Q. Why do you say that?

09:51:03 A. Because in the month of August, Jim, who would have been the principal researcher -- I'm sorry, the researcher would have been in the car in the course of doing those trials, those drivings, was working very hard to finish his thesis. And it is certainly possible that driving would have occurred, but I think it's highly unlikely because I think at that point he had a very large document to produce.

09:51:35 Q. Let's talk about the system as it existed in June and July of 1989.

09:51:45 First of all, is there any reason to believe that any changes to the Back Seat Driver took place between June and July of 1989 or can we talk about that as one system?

A. There is no record of any changes. However, it's highly likely that there were changes.

Q. What do you say that?

A. Because at that time Jim was working very hard on finishing learning what he needed to learn and making the modifications to the software that he needed to make in order to call his thesis complete. The purposes of these test drives was to debug and evaluate his software. Therefore, if he learned anything and during any one of these drives, he almost most certainly would have fixed that in which case each subsequent drive would have had different possible behavior.

Q. As M.I.T.'s designee for topic seven of the 30(b)(6) notice, are you aware of any changes that were made to the Back Seat Driver System between June of 1989 and July of 1989, that would relate to whether any of the asserted -- any of the limitations of the claim of the '685 patent were or were not embodied in those field trials?

MS. MOTTLEY: I'm going to lodge an objection on the record. I don't think that question is within the scope of today's deposition. I'll give you a little leeway and see where you're going.

A. That was a very long question. I'm not sure

objection.

MR. LEAVELL: You can shorten it that way, if you want.

A. Okay. What's the question on the table?

Q. How do you know the changes were made to the Discourse Generator after June of 1989?

MS. MOTTLEY: Same objection.

A. Because the changes that Jim Davis would have been working on to complete his thesis would have been aspects of the Discourse Generator.

Q. How do you know that?

MS. MOTTLEY: Same objection.

A. Because I was his thesis advisor.

Q. What changes were made with the Discourse Generator between June of '89 and August 9 of 1989?

MS. MOTTLEY: Same objection.

A. I don't have a change log. I can't tell you.

Q. Is there a change log?

MS. MOTTLEY: Same objection.

A. No.

Q. Do you have in your mind as you're answering these questions, a particular change that was made to the Discourse Generator, but you're just not sure when it took place?

10:04:30 discourse including instructions and other messages?

10:04:34 MS. MOTTLEY: Same objections, outside the

10:04:35 scope and calling for claim construction.

10:04:37 BY MR. LEAVELL:

10:04:37 Q. For directing the driver to the destination

10:04:41 from the current position?

10:04:44 MS. MOTTLEY: Same objections.

10:04:45 A. And I'm again, I'm going to have to ask you to

10:04:47 repeat that.

10:04:48 Q. Sure.

10:04:48 As of June of 1989, were you and

10:04:52 Mr. Davis reasonably sure that you had developed a

10:04:55 Discourse Generator that would work for its intended

10:04:57 purpose as of that date?

10:04:59 MS. MOTTLEY: Same objections.

10:05:09 A. Clearly, we believed that there was

10:05:10 something -- that we had built something that was

10:05:12 beginning to work. We didn't believe it was a finished

10:05:14 product or product not something for sale. Product

10:05:21 means a piece of research. There were certainly changes

10:05:27 that needed to be made. There were certainly -- during

10:05:33 that time period there were certainly changes that

10:05:35 needed to be made in order for Jim to -- for us to

10:05:38 consider the work to be completed enough for Jim to get

his thesis.

Nonetheless, in June, we certainly -- we both would have predicted with relative confidence that Jim's thesis was going to be finished at the end of the summer.

Q. And the summary on Exhibit 91, it says, this is on the second page, it says: The Back Seat Driver is already working in prototype form.

Was that a true statement? Was the Back Seat Driver working in prototype form as it existed in June of 1989?

MS. MOTTLEY: Objection; outside the scope.

A. Yes, it was.

Q. And it was already working as a prototype system that included each of the limitations in Claim 1 of the '685 patent in June of '89; is that correct?

MS. MOTTLEY: Objection; outside the scope.

A. Yes, that's correct.

Q. What about Claim 2 of the '685 patent, did the Back Seat Driver, as it existed in June of '89 and was working in prototype form in field trials, include the subject matter recited in Claim 2 of the '685 patent?

MS. MOTTLEY: Objection as outside the scope and also objection to the extent that you're asking

10:08:27 Q. Thank you.
10:08:31 What about Claim 3 in the '685 patent, did the Back Seat Driver, as it existed in the successful field trials in June of '89, include the subject matter recited in Claim 3 of the '685 patent?
10:08:47 MS. MOTTLEY: Same objections.
10:08:49 A. I'm concerned because suddenly you've introduced this word, successful. You refer to successful field trials.
10:08:56 Q. Let me rephrase --
10:08:57 A. There was not any particular metric of success in these.
10:09:01 Q. Let me rephrase.
10:09:03 Was the Back Seat Driver, that was already working in prototype form in field trials in June of '89, include the subject matter recited in Claim 3 of the '685 patent?
10:09:14 MS. MOTTLEY: Same objections.
10:09:15 A. Yes, it did.
10:09:16 Q. How do you know that?
10:09:17 A. Because all --
10:09:18 MS. MOTTLEY: Same objections.
10:09:19 THE WITNESS: Sorry.
10:09:19 A. Because all field trials of the Back Seat

11:05:15 thesis or not so that he can -- to aid his
11:05:17 testimony. You can mark that as an exhibit.
11:05:19 MR. LEAVELL: Let's go ahead and mark this as
11:05:20 an exhibit.
11:05:21 MS. MOTTLEY: I don't think we put 15 on any
11:05:23 other category because he had already testified
11:05:26 about it, but maybe we did. We did, I think.
11:05:32 MR. LEAVELL: Could we mark this?
11:05:35 THE WITNESS: No, 15 isn't on there.
11:05:41 MS. MOTTLEY: 15 should be in the --
11:05:43 MR. LEAVELL: We're on the record.
11:05:44 MS. MOTTLEY: That's fine.
11:05:46 15 should be in the -- yes, so you can add
11:05:51 that in your own handwriting when he gives it back
11:05:55 to you.
11:06:15 (Exhibit 92 Marked for Identification)
11:06:17 BY MR. LEAVELL:
11:06:17 Q. We've marked as 92, your handwritten list.
11:06:20 And what that indicates is which claims were present in
11:06:27 the Back Seat Driver as it existed as an actual working
11:06:35 prototype as of August 4th, 1989, and had by that time
11:06:41 successfully guided drivers unfamiliar to Cambridge to
11:06:44 their destinations.
11:06:45 Those claims that fall within that are

11:06:50 listed as a Yes on your list; is that correct?

11:06:53 A. That's correct.

11:06:55 Q. And which claims are those, according to your

11:06:57 list?

11:06:57 A. 15, 19, 20, 21, 23 through 37 inclusive, 40

11:07:12 through 49 inclusive, 51 through 55 inclusive, 57 and

11:07:21 58.

11:07:24 Q. And the other category on your sheet are

11:07:29 identified as Not; and which claims are those?

11:07:34 A. 13, 14, 16, 17, 18, 20, 22, 38, 39, 50 and 56.

11:07:54 Q. For each of those claims that are identified

11:07:56 as Not on Exhibit 92, is it true that M.I.T. never made

11:08:04 a system that embodied the subject matter in any of

11:08:08 those claims?

11:08:09 MS. MOTTLEY: Objection, beyond the scope and

11:08:12 compound and calling for testimony based on the

11:08:15 claim construction the Court has not yet rendered.

11:08:18 A. No, that's not what I meant by Not.

11:08:21 Q. What did you mean by Not?

11:08:24 A. That by Not, I meant that we don't have

11:08:26 documentation that those were implemented as of the

11:08:31 August 1989 date.

11:09:44 Q. Did the Back Seat Driver, as it existed as an

11:09:50 already working in prototype form in field trials in

it through 42 through 47 and deal with 48 and 49, but whatever the witness needs to do.

MS. MOTTLEY: Sure.

A. Okay. To make sure I'm answering the proper question, the question was as of June of 1989?

Q. Right. The question is: Did the Back Seat Driver, as it existed as a working prototype in field trials in June of 1989, include the subject matter of Claims 42 through 49?

A. We don't know.

Q. Why not?

A. Because we have no documentation that tells us when those features were added to the system.

Q. If those features were included in the database of the Direction Assistance Program, is it reasonable to assume they were carried over to the Back Seat Driver System?

MS. MOTTLEY: Same objections.

A. No, it is not.

Q. Why not?

MS. MOTTLEY: Same objections.

A. Because these aren't -- these claims don't apply to databases. They apply to what's spoken.

Q. But the Back Seat -- or the Direction

been identified to testify as to topic three.

BY MR. LEAVELL:

Q. Subject to that qualification that's correct, right?

A. Yes.

Q. Is there any evidence to show that any steps were taken to protect the confidentiality of Mr. Davis' thesis paper or any drafts of the same prior to August 9th, 1989?

A. The thesis didn't exist until that time.

Q. Well, there were drafts of the thesis prior to August 9th of 1989, correct?

A. The drafts, yes, there were drafts of the thesis.

Q. And the final thesis itself was dated or signed on August 4th of 1989?

A. That's correct.

Q. So the final version that was signed by Mr. Davis existed five days before August --

A. Okay; fine.

Q. -- 4th, 1989, correct?

A. Yes.

Q. Is there any evidence that anyone took any steps to preserve the confidentiality of Mr. Davis'

thesis paper or drafts of his thesis paper at any time prior to August 9th, 1989?

A. Yes.

Q. What is that evidence?

A. The thesis was received at the M.I.T. library on February 27, 1990. The date is stamped on the thesis and has been verified with library. That means the thesis was not turned over to the library for public dissemination until February 27, 1990.

It was not shelved until September 1990, nor was it cataloged until that time. That's normal M.I.T. library delay.

Q. Well, that's the final version. My question was directed to drafts of the thesis.

Is there any evidence that Mr. Davis took any steps to protect the confidentiality of the draft thesis paper or the thesis paper itself prior to August 9th of 1989?

A. Certainly, the drafts of the thesis were on a password protected computer. The computer itself physically was in a room that had a keypad combination.

Q. And where was that computer at?

A. M.I.T. Media Lab, third floor.

Q. So if Mr. Davis wanted to work on his thesis

13:51:07 paper, he had to do it at that particular computer?
13:51:09 A. Yes.
13:51:09 Q. He was not allowed to have a copy of the paper
13:51:13 on his own computer to work on?
13:51:14 A. He certainly would have been allowed to, but
13:51:16 he did not have a computer in his possession that had
13:51:18 the particular document creation facility that the
13:51:21 thesis was done on.
13:51:22 Q. What particular document creation?
13:51:27 A. I believe there's a LaTex document.
13:51:31 Q. A what?
13:51:29 A. LaTex; L-A-T-E-X, capital L, capital T.
13:51:37 Q. How do you know it was that type of document?
13:51:40 A. Because it looks like it.
13:51:42 Q. What makes it look like a LaText document?
13:51:49 A. The variety of the fonts used, the way the
13:51:53 chapter headings and subheadings are laid out, the way
13:51:57 bullets are done, the way figures and graphs are done,
13:52:08 the bibliography. I know for a fact that Jim Davis used
13:52:15 LaText for the his bibliography format because we shared
13:52:20 the same bibliography files. LaText allows you to have
13:52:24 a large bibliography file and then extract particular
13:52:27 sources that you which to cite.
13:52:29 In fact, portions of that file are still

13:52:33 in use today; plus it is my knowledge as somebody who
13:52:40 was in charge of some graduate thesis work at the Media
13:52:45 Lab and done at that time thesis which was only done in
13:52:47 LaText as well as most of our publications.
13:52:55 Q. So the editing that Miss Quad (P), Mr. Bender,
13:53:01 Mr. Dresser and Miss Druhecker did, all took place at
13:53:05 the Media Lab at this one computer?
13:53:07 A. They presumably would have edited hard copy.
13:53:13 Q. So there were copies of the thesis that
13:53:15 existed other than on that password protected computer,
13:53:20 correct?
13:53:22 A. Jim could print a copy whenever he wanted and
13:53:24 give that to anybody that he wanted to.
13:53:28 Q. So you didn't mean to imply the fact that the
13:53:30 thesis was on a password protected computer in the Media
13:53:34 Lab, that that excluded the possibility that anybody
13:53:38 printed out and shared copies of the thesis?
13:53:40 A. That limits the number of people who could
13:53:42 print out and share copies of the thesis to
13:53:45 approximately two.
13:53:46 Q. How does it do that?
13:53:47 A. Jim Davis and myself are the ones who had
13:53:49 access to the document.
13:53:50 Q. All right. But Jim Davis could have printed it

13:53:52 out and shared it with anybody he wanted, right?
13:53:55 A. He could have. Like I said, there were two
13:53:58 people that could have done that; Jim Davis and myself.
13:54:11 Q. Who did you talk to to determine when the
13:54:15 thesis paper was shelved and cataloged in the M.I.T.
13:54:19 library?
13:54:21 A. Somebody at the M.I.T. library. I forget her
13:54:26 name.
13:54:26 Q. What was she -- was she at the reference desk
13:54:27 or what department? How did you find her?
13:54:29 A. I don't actually know. Karin Rivard got the
13:54:30 information from her.
13:54:34 Q. Who is that?
13:54:34 MS. MOTTLEY: Counsel.
13:54:34 BY MR. LEAVELL:
13:54:39 Q. So counsel talked to somebody at the M.I.T.
13:54:41 library and counsel told you that that's when the thesis
13:54:44 was shelved and cataloged?
13:54:47 A. This is M.I.T. counsel. I know when the
13:54:49 thesis was received at the M.I.T. library intrinsically
13:54:52 because that's the date that's stamped on it. You'll
13:54:55 see it on your copy there on the bottom center.
13:55:10 Q. Is there any other evidence that M.I.T.
13:55:16 contends supports any steps that were taken to preserve

13:55:22 the confidentiality of Mr. Davis' thesis paper or drafts thereof during the time period prior to August 9th of 1989?

13:55:32 A. It's generally University policy, and M.I.T. is no exception, that drafts of documents such as thesis are not public. They are not to be distributed publicly.

13:55:42 Q. Anything else?

13:55:43 A. No.

13:55:46 Q. Is there any evidence that the M.I.T. Media Laboratory Speech Group reports that are identified in topic No. 2 were the subject of any steps to preserve their confidentiality during the time period of August 9, 1989?

13:56:06 A. They weren't published.

13:56:08 Q. Anything else?

13:56:11 A. In order for them to distribute it, I probably would have had to know about it.

13:56:15 Q. What do you mean by, Probably Would Have Known about it?

13:56:18 A. The documents were stored in a closest. Somebody could have come in and stolen them. The normal operating procedure if somebody wanted a document -- and first of all they, would have to know they existed which

CORRECTIONS TO 30 (b)(6) DEPOSITION TRANSCRIPT
OF M.I.T. through CHRISTOPHER M. SCHMANDT
May 19, 2006

MASSACHUSETTS INSTITUTE OF TECHNOLOGY V. HARMAN INTERNATIONAL INDUSTRIES INC., C.A. NO. 05-10990-DPW

Page	Line	Change/Correction	Reason
14	24	Change “defendant” to “dependent”	Transcription error
18	10	Change “Digestive” to “Digest of”	Transcription error
53	18	Change “best search” to “best first search”	Transcription error
64	22	Change “GP” to “GPS”	Transcription error
77	15	Change “name” to “names”	Transcription error
114	15	Change “LaText” to “LaTex”	Transcription error
114	20	Change “LaText” to “LaTex”	Transcription error
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I have read the foregoing transcript of my deposition and except for the corrections and changes noted above, I hereby subscribe to the transcript as an accurate reflection of the statements made by me.

Christopher M. Schmandt

EXHIBIT 12

UROP PROPOSAL

Gregory Grove
233 Massachusetts Avenue
Cambridge, MA 02139
April 10, 1989

The **Backseat Driver** is a system for maintaining a moving vehicle's position, speed, and direction, and directing the operator of the vehicle to a specific destination. This system could be generalized to any type of vehicle or location, but the actual research simulation is restricted to a car moving within Boston city limits. The positioning and directing system is controlled by computer and gives the driver of the car spoken commands indicating when to turn, and what streets the driver is crossing.

The link between the computer and the car is maintained by a laptop computer with a modem, hooked up to a cellular phone. Currently, the positioning system is maintained by the laptop. In order for the main computer to know where the car is, the carrier between the modems must remain intact. Unfortunately, loss of carrier occurs frequently. I will be in the car monitoring the carrier status and operating the positioning system. When the carrier is lost, I will log the time, location, and conditions surrounding the loss of carrier. I will investigate why the carrier was lost. My investigation will attempt to show why the carrier is being lost, or at least demonstrate a pattern for carrier loss, so that the problem can be eliminated. Firm establishment of cellular phone/modem communication would benefit the project by making it a much more viable system.

I am an electrical engineering major, and this UROP will provide me with practical experience with signal processing. I will be investigating the operation of cellular phones, possible equipment problems, signal/noise problems, and reaction of cellular phone signals to various disruptions. I wish to receive credit for my efforts. My supervisor will be Chris Schmandt.

Chris Schmandt
Supervisor

Gregory Grove

EXHIBIT 13

Analysis of the Viability of Cellular Telecommunication and Probability of Carrier Loss Using the UNIDEN CP1200 and NEC 4500 Cellular Telephones

UROP Final Paper

Gregory Grove

May 20, 1989

This term I was involved in a UROP with the media lab in cellular telecommunications. I worked on an application called the "Backseat Driver." It was my job to maintain the cellular modem connection with a LISP machine that was issuing directions to the driver of a car. Every time the carrier between the laptop computer I was using in the car and the LISP machine was dropped, I logged the time and circumstances surrounding the loss of carrier so I could try to find a correlation between the loss of carrier and something.

Unfortunately, I wasn't able to gather enough data over the term to do anything more than calculate the probability of a loss of carrier with respect to time, and extrapolate mean call times for the two cellular phones being used. Nonetheless, I really enjoyed my UROP and felt that I learned a great deal. This UROP gave me a chance to work on an application, which is something I'd never done before. In the past I had learned a lot of theory that applied to this project, but I found that theory is indeed quite a long way from application. I learned some of the problems associated with doing application work, and I consider myself fortunate to have learned through this UROP. Later in life, when I'm working on an application of my own, I think these learning experiences will help me and save me a lot of time.

Overall, I have a positive feeling about my UROP experience, but there were some things I would have changed. First, and most importantly, I didn't really feel like part of the team working on the program. I realized that I was an integral part of the operation of the Backseat Driver, in the sense that it

really couldn't work without me communicating with the LISP machine from the car, but I never got to do any developmental work of any sort, and I never really got to suggest changes or see the process of having changes implemented. I am reasonably proficient in LISP, yet I never was able to see the code of the program running the Backseat Driver. In fact, I was apologized to when I "had to type some ugly expression into LISP." When I was dealing with LISP, I felt pretty good that I understood what commands I was issuing to the LISP machine. If I could have changed this situation, I would have been given some responsibility for analyzing code, and coming up with suggestions for improvements. Second, I don't think that my "official" job was substantial enough. There really wasn't enough data to do anything with. If there was a couple of years worth of data including weather conditions, location of loss of carrier, and time of day I might have been able to come up with some interesting conclusions, and maybe even a suggestion for improving cellular telecommunications. However, as it stood, I could do little more than calculate the probabilities for loss of carrier. I feel that a little more responsibility and a different "official" purpose for this UROP would have made it better.

I appreciate the opportunities that this UROP has afforded me and I thank my supervisors at the MIT Media Lab for the valuable experience I have gained. I really enjoyed my UROP this term. I am looking forward to another UROP in the future.

Gregory Grove

EXHIBIT 14

TO BE FILED UNDER SEAL

PURSUANT TO MIT'S ASSENTED-TO MOTION TO FILE UNDER SEAL (DOCKET NO. 158)

EXHIBIT 15

TO BE FILED UNDER SEAL

PURSUANT TO MIT'S ASSENTED-TO MOTION TO FILE UNDER SEAL (DOCKET NO. 158)

EXHIBIT 16

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF MASSACHUSETTS

MASSACHUSETTS INSTITUTE OF TECHNOLOGY, Plaintiff, v. HARMAN INTERNATIONAL INDUSTRIES, INCORPORATED, Defendant.	Civil Action No: 05-10990 DPW

REBUTTAL EXPERT REPORT OF M. ELIZABETH CANNON, PH.D.

I. Streeter

114. The French Report asserts that claims 1, 2, 7-9, 11-13, 19, 21, 23, 24, 27-29, 32, 34, 35, 36, 40-46, 48, 49, 54, and 56 are invalidated by the *Streeter* reference, either alone or in combination with other prior art.

115. The French Report refers to an article co-authored by Lynn Streeter, Diane Vitello, and Susan Wonsiewicz entitled *How to Tell People Where to Go: Comparing Navigational Aids* ("*Streeter*") (HAR000192-HAR000206).

116. Dr. Streeter's report contains a section discussing *Streeter*. I believe that *Streeter* does not invalidate the claims of the '685 patent because the claims of the '685 patent are not taught or suggested by *Streeter*. Moreover, the French Report has not shown by clear and convincing evidence that the claims of the '685 patent are invalid over *Streeter*. I do not intend my testimony at trial to be redundant, but if asked, am prepared to discuss *Streeter*, along the lines of Paragraphs 44-46 and 47-57 of Dr. Streeter's Report, attached hereto as Exhibit H and incorporated by reference.

J. Field Trials/Public Use

117. Harman has alleged that all of the asserted claims of the '685 are unenforceable because field trials conducted by Davis and Schmandt from April 1989 through August 1989 were not cited to the U.S. Patent and Trademark Office during prosecution of the '685 patent.

118. I understand that the field trials were conducted using MIT undergraduate students who drove an automobile equipped with a test prototype of the Back Seat Driver system. MIT1101; MIT06763; MIT06765. The field trials consisted of a driver driving an

automobile and a researcher, also in the car, observing the conduct and reactions of the driver. MIT06763; MIT06765. During the field trials, computing equipment was at the Media Lab at MIT. Schmandt Dep., p. 161, ll. 3-23; MIT1101. From the perspective of the driver, the experiment involved: (a) allowing a researcher to enter a destination via a keypad of a first cellular telephone, (b) awaiting an instruction to begin driving from the speaker of a second cellular telephone, (c), in response to receiving an instruction to being and a first driving instruction, maneuvering the vehicle, and (d) following subsequent driving instructions. MIT06765. The driver never had access to or otherwise observed the operation of at least the following components of the Back Seat Driver system as claimed in the ’685 patent: (a) the computing apparatus, (b) the map database, (c) the position sensing apparatus, (d) the location system, (e) the route-finder, or (f) the discourse generator. See MIT06765.

119. The researcher in the vehicle observed the output of the second cellular telephone and the driver’s reaction to that output. MIT06763; MIT06765. The researcher made note of the driver’s reaction and considered ways to improve the components of the Back Seat Driver system as a result. MIT06763; MIT06765. After a particular field trial ended, the researcher was able to improve the operation of the system by making changes to any of the components of the Back Seat Driver system.

120. Because the driver did not have access to at least 6 components of the Back Seat Driver system, as claimed in claim 1 of the ’685 patent, there was no use by the driver of the claimed invention; instead, the driver reacted to the output of the claimed invention. Both the output and the back-end algorithms were evolving in response to the field trials. Because there was no use of the invention by the driver, axiomatically, the field trials did not amount to public

use of the claimed invention. For at least this reason, the field trials were not material to the patentability of the claims of the ’685 patent.[2]

K. Harris and Calgary AVL System

121. Throughout the French Report reference is made to Harris, *Digital Map Dependent Functions of Automatic Vehicle Location Systems* (“Harris”) (MIT01092-MIT01100) in support of the invalidity of various claims or limitations thereof. I am familiar with this research prototype and the work that had been done at the University of Calgary in Automatic Vehicle Location Systems both before and after this paper was authored. In addition, I worked with the authors of this paper Clyde Harris, Laurie Klesh, Edward Krakiwsky, Hassan Karimi, and Ness Lee. The French Report uses Harris to support the allegation that the claims of the ’685 patent are invalid. See French Report pp. 8, 14, 15, 18, 22, 24, 26, 28, 30, 57, and Exhibit L. In view of Harris, it is my opinion that this research prototype does not anticipate or render obvious any of the claims of the ’685 patent at least because the system described in Harris did not contemplate speech generation or discourse generation. The system described by Harris lacked the sophistication to provide verbal instructions. Moreover, the “Route Guidance” text and context of Harris suggests that the functionality described had not been implemented. MIT01097. The type of instructions displayed or presented aurally to the driver were considered but not completed.

[2] In the event that the Court deems the driver’s exposure to the outputs of the Back Seat Driver system to be use, such use did not occur publicly, at least because the driver was not exposed the computing apparatus as it operated at the Media Lab during the field trials. Moreover, an observer viewing the driver maneuvering the automobile could not know that the car was being driven by a driver who was receiving real-time spoken instructions from the Back Seat Driver system. Finally, in the university setting, there is an ethical obligation on students not to disclose the work of another, and therefore, work disclosed to students in labs is not considered a “public” use.

The foregoing Rebuttal Expert Report of M. Elizabeth Cannon, Ph.D, in connection with the patent infringement action between MIT and Harman, is submitted as of the date below, having been prepared and reviewed by the undersigned.

Dated: August _22, 2006

M. Elizabeth Cannon, Ph.D.

EXHIBIT 17

Consent to be Experimental Subject with the Back Seat Driver.

We are required by regulations to obtain documentation of your informed consent in this experiment. Please read it carefully.

By my signature below, I understand that:

1) I will be asked to drive our car to various destinations in the Boston area selected by the experimenters. While driving, I will hear synthetic speech instructing me where to drive. At all times, at least one experimenter will be in the car with me, but this person will not answer questions while the experiment is in progress, unless my safety requires it.

2) Discomforts and risks: I will drive in traffic. I understand that driving in Boston is a stressful, and sometimes hazardous activity. My first concern in driving will be my safety.

3) There is no benefit to me in participating.

4) I will not participate in this experiment if I do not feel comfortable driving, because of weather, traffic, or any other reason.

5) The investigators will answer any questions I have about the procedure.

6) Withdrawal: I may stop the experiment at any time by stopping the car in a safe place.

7) I do not waive any rights by signing this form.

8) In the unlikely event of physical injury resulting from participation in this research, I understand that medical treatment will be available from the M.I.T. Medical Department, including first aid, emergency treatment and follow up care as needed, and that my insurance carrier may be billed for the cost of such treatment. However, no compensation can be provided for medical care apart from the foregoing. I further understand that making such medical treatment available, or providing it, does not imply that such injury is the Investigator's fault. I also understand that by my participation in this study I am not waiving any of my legal rights.

9) If I feel I have been treated unfairly as a subject I may contact the Chairman of the Committee on the Use of Humans as Experimental Subjects, MIT 253-6787

10) I hold a valid drivers license.

Signed________________________________

Print Name___________________________ Date __________________

EXHIBIT 18

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
77 MASSACHUSETTS AVENUE
CAMBRIDGE, MASSACHUSETTS 02139

E23-389 3-6787
COMMITTEE ON THE USE OF HUMANS AS EXPERIMENTAL SUBJECTS

COMMITTEE APPROVAL

DATE: 01/20/89

TO: Christopher Schmandt
E15-327

FROM: H. Walter Jones, Jr., M.D.
Chairman

APPLICATION NO.: 1881

TITLE: Back Seat Driver

RENEWAL DATE: 01/20/1989

Your application has been approved by the Committee on the Use of Humans as Experimental Subjects at its meeting on 01/19/89. This approval is valid until one year from the above renewal date, at which time your entire application will be due for annual review.

It is expected that you will notify the Committee of any further changes in your protocol, and also inform the Committee when your project is terminated. The COUHES number assigned to your project is 1881. In the future, please note this number on all correspondence referring to this project.

cc: T. Duff, OSP

1881 X

E15-327
22 Dec. 1988

Dear Dr. Jones,

This is further information with regards to your letter of 19 Dec. on our "Back Seat Driver" project.

The vehicle is MIT owned. As such, it and its occupants are covered by the blanket MIT vehicle policy. The Media Lab currently owns two other vehicles, both of which are used to convey students between E15 and off campus research facilities, on a daily basis. I can, of course, have Tom Henneberry confirm this if you wish.

While testing the Back Seat Driver, the car will never be driven without a research team member along, for several reasons. Most important, of course, is that the whole point of doing road trials is to observe actually using the system. Secondly, any audio or video recording will be done by the observer in the car. Thirdly, the research team member will be required to operate the computer equipment and cellular telephones in the car.

Since the driver is never alone, and is in fact accompanied by experienced local drivers with a thorough map database available, there is no fear of getting lost. We will be chosing the routes for the road trials, and would of course avoid any unsafe neighborhoods! In fact most of the driving will be in Cambridge, within a few miles of MIT.

We have no plans to drive during bad weather or unsafe road conditions; besides safety, this would result in non-uniform test data as subjects would be strained by the environmental factors. We may do some night driving, but this would be in the early evening, hardly in the middle of the night. And as for breakdowns, we have just purchased a brand new car so our vehicle is in excellent condition.

Presumably most of your concerns were based on the assumption that the driver would be alone, and I hope I have clarified that. I will ask Jim to submit a copy of the detailed proposal to you, and to verify insurance coverage with Tom Henneberry.

Please feel free to contact either of us for more information or proceedural suggestions.

Sincerely,

Chris Schmandt

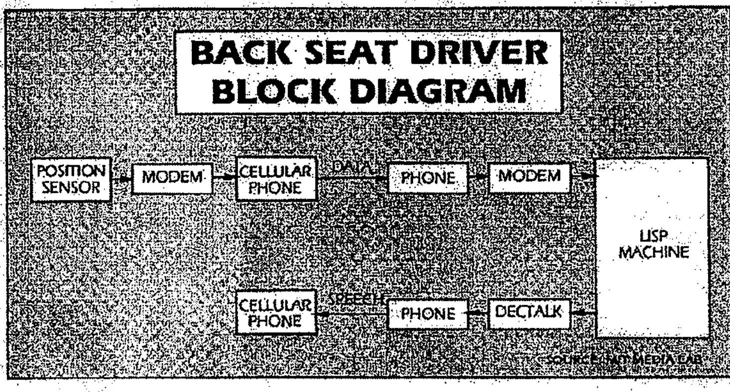
Chris Schmandt
Director, Speech Research Group

HIGHLY CONFIDENTIAL

EXHIBIT 19

Prototype Guidance Unit Uses Speech Synthesis

By DEAN TOMASULA



CAMBRIDGE, Mass. — Researchers at the Massachusetts Institute of Technology's Media Laboratory have developed a prototype guidance system that uses speech synthesis as a navigation aid.

The system, called the Back Seat Driver, gives directions in real time, the researchers said, in addition to planning and talking the driver through a route, warning the driver when he makes a wrong turn and advising him of an alternative route.

The Back Seat Driver, developed by MIT researchers Christopher M. Schmandt and James R. Davis, is a dead-reckoning system that uses a database stored on CD-ROM for map-matching, much like competitive navigation systems. The hardware is provided by NEC Home Electronics Ltd., which is sponsoring the project.

Two cellular telephones link a base computer to the car. The Back Seat Driver transmits the car's position and speed back to the lab's computer via modem and telephone. Since the system is only a research prototype, Mr. Schmandt pointed out, much of the computation is done by the base computer. A production system would use an on-board computer for route planning.

Speech synthesis is performed by a commercially available Dectalk text-to-speech synthesizer, which is connected to a Symbolics LISP Machine. Synthesized instructions are relayed to the driver through the second cellular phone, which is a speakerphone. The keypad of that phone also serves as the driver's control unit for the system, allowing him to select a destination and request a repeat of previous instructions.

"MOST PROTOTYPE projects have used various forms of display to present this information, and not all have included route-finding ability," said Mr. Schmandt. "For safety reasons, a display may not be particularly suited to this task." He added that some drivers do better following spoken directions than reading a map.

He also said that when directions are being given to a driver by a passenger, the real-time aspect of the instructions becomes important. The Back Seat Driver gives "just in time" directions, taking into account vehicle speed, the difficulty of the expected maneuver, driving styles and road, weather and traffic conditions.

> "For safety reasons, a display may not be particularly suited to this task"

The Back Seat Driver's database currently covers 41 square miles, including parts of the Massachusetts cities of Boston, Cambridge, Brookline, Somerville and Watertown. The database is taken from the U.S. Geological Survey's DIME (Dual Independent Map Encoding) files.

The researchers pointed out that a DIME file alone is not sufficient for accurate route finding when used in cars. A file consists of a set of straight lines, each with a name and endpoints in latitude and longitude. Additional information such as address numbers also is included.

While the DIME files indicate physical connectivity — such as streets that intersect — it does not indicate legal connectivity. Because two streets physically intersect, it doesn't necessarily mean it is legal to drive from one to the other. For example, one of the connecting streets may run one way in the opposite direction.

THE MIT RESEARCHERS said they are currently adding landmarks to the database, such as traffic lights, stop signs, and some buildings. They also are including lane information — the number of lanes on a given road, as well as any turn restrictions on those lanes.

Since the driver cannot see the system, the Back Seat Driver periodically lets the driver know it is still working by giving warnings and reassurance. The system will acknowledge a driver's correct action with a "nice work" or "good." If the driver is approaching a turn too fast, the system will tell him to "slow down" before taking the turn.

One of the more complex set of instructions the Back Seat Driver can give is as follows: "Get in the left lane because you're going to take a left at the next set of lights. It's a complicated intersection because there are two streets on the left. You want the sharper of the two. It's also the better of them. After the turn, get into the right lane."

Mr. Schmandt said, however, that it isn't clear how much "chattiness" a driver will accept from a synthetic voice. "Certainly this feature could be useful in a rented car in a new city, where it might have some interesting things to say."

The next step in the Back Seat Driver's development, according to the researchers, is to determine exactly what a speech guidance system should say, how time and vehicle speed affect the instructions it gives, and what features a map database must have to support the generation of useful spoken instructions.

INTRODUCTION THIS FALL

Sony to Offer Portable CD Player for In-Car Use

NEW YORK — Sony will introduce to the aftermarket this fall a portable CD player that it said was specifically designed for use in cars.

The D-180K Discman, said Shin Kobayashi, vice-president of general audio, was developed because research proved that one-third of the company's Discman units were purchased for use in cars. The D-180K also can be used as a portable CD player and at home.

The unit features a dual damping suspension to help guard against road bumps. Mr. Kobayashi said the improved anti-shock qualities of the unit make the need for a suspension mounting plate unnecessary.

THE D-180K HAS been designed for ease-of-use while driving, he said. It features oversize function controls and an orange backlit function display light and play button that are said to be easy to see in daylight or at night.

The D-180K has an oversampling digital filter to help minimize noise and improve high frequency response and features a three-spot laser optical pickup. An automatic tracking recovery mechanism disengages the laser during severe bumps and then returns it to the same spot.

THE UNIT CAN play both 5-inch CDs and 3-inch CD singles without an adaptor. It comes with a dc cable for connecting it to the car battery through the cigarette lighter. Also supplied with the D-180K are an ac adaptor for home use and a rechargeable battery.

Also supplied with the unit is a CPA-2 cassette adaptor that permits the D-180K to be played through the car's speakers. An optional CPM-70 kit allows the unit to be permanently installed in the car on a mounting arm.

The D-180K will retail for $260.95.

It will also has an optional RM-DM2 Remote Commander remote control unit for use while driving. □

GOING MOBILE: Sony's D-180K portable CD player was specifically designed for use in automobiles and features oversize control buttons.

EXHIBIT 20

TO BE FILED UNDER SEAL

PURSUANT TO MIT'S ASSENTED-TO MOTION TO FILE UNDER SEAL (DOCKET NO. 158)

EXHIBIT 21

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF MASSACHUSETTS

MASSACHUSETTS INSTITUTE OF TECHNOLOGY, Plaintiff, v. HARMAN INTERNATIONAL INDUSTRIES, INCORPORATED, Defendant.	Civil Action No.: 05-10990 DPW Magistrate Judge Judith G. Dein

DECLARATION OF JAMES R. DAVIS, PH.D.

I, James R. Davis, Ph.D., state the following:

1. I am an inventor on U.S. Patent 5,177,685, which is based on my Ph.D. research project called the "Back Seat Driver," which provided intelligent spoken instructions in an autonomous vehicle navigation system.

2. Harman says in its Statement of Undisputed Facts ("SUF") that I could have printed a draft of my thesis and given it to anyone I wanted. SUF, para. 5. Although I *could* have done it, it was not my normal practice to print copies of my draft thesis and give it to the general public. I am not aware of any evidence to suggest the contrary.

3. Harman says that "On July 31, 1989, Davis and Schmandt sent a copy of the completed thesis ('certified by Nicholas P. Negroponte,' then director of the MIT Media Lab) to a Mr. Rittmueller, an NEC employee at the time." SUF, para. 6. I believe Harman is wrong. I do not recall sending a copy of my thesis to Mr. Rittmueller before it was published.

4. Harman says that "Davis himself sent another copy of his thesis (unsigned by bearing an August 4, 1989 date for Davis' signature) to a Bell Labs employee, Lynn Streeter, without any confidentiality designation and without any restrictions on her use of it." SUF, para. 8. I do not recall sending a copy of my thesis to Lynn Streeter before I defended my thesis. Streeter was a professional and academic colleague who, if she had received a copy of my thesis from me, would have received my thesis with a view towards providing feedback and comments because she had done valuable and groundbreaking research in the field of direction-giving. As an academic, I would have considered Lynn bound by the ethical obligations regarding my thesis to not publish it as her own or otherwise freely distribute it, so no written "restrictions" were necessary.

5. Harman says that "In May 1989, after requesting from Davis a copy of 'any papers [Davis had] written about [the Back Seat Driver],' a University of Minnesota student responded to Davis that she could 'wait a couple weeks to see [Davis' T]hesis." SUF, para. 10. I do not believe I sent a copy of my thesis to this student in May 1989 or any time thereafter, and the email Harman points to does not show that I did. I earned my Ph.D. from MIT in September 1989, and my thesis was not ready for defense or distribution in May 1989.

6. Harman alleges that "By May 26, 1989, Davis was prepared to defend his thesis and invited the public to attend." SUF, para. 12. I was not prepared to defend my thesis on May 26, 1989. The "flyer" inviting the "public" to attend was a draft, as can be seen from the handwritten corrections and various typos in the flyer. I may have thought at one time that my thesis would be ready to defend on May 26, 1989, but in fact, it was not ready to defend until sometime later in the summer. My original goal was to graduate in June of 1989, which explains why I would have wanted to defend my thesis in May. However, Chris Schmandt and I recognized that the Back Seat Driver project needed some additional work before I could get my degree, and so we worked on additional prototypes over the summer of 1989. As a result, we were able to build and test an operational system by the end of the summer, which resulted in my thesis defense and graduation in the fall of 1989.

7. Harman says "When MIT submitted its Response to the First Office Action, MIT knew that Davis had actually distributed his thesis and that he did so more than once." SUF, para. 29. I believe that the only people who were given drafts or finalized versions of my thesis in 1989 were the actual members of my thesis committee or colleagues acting in an academic advisory capacity concerning the content of my thesis.

8. Harman states that "During prosecution of the '685 Patent, Davis knew that 50 subjects had used the Back Seat Driver between May 1, 1989 and July 31, 1989 and after Davis knew the Back Seat Driver would work." SUF, para. 57. Harman does not specify which version of the Back Seat Driver project was used by these test subjects. I believe Harman is referring to the "subjects" being used in an experiment to test a prototype of the system. For the driving experiments we conducted with undergraduate students, either Chris or I would ride along in the vehicle to observe the driver's performance and evaluate the user interface. Under the experiment's protocol, one of us was always in the car for test drives. This was required by the MIT Committee of the Use of Humans as Experimental Subjects. Contrary to what Harman says, although Chris and I were confident that the Back Seat Driver would work by June of 1989, we needed to continue field trials to ensure that the system was safe, effective, durable and repeatable.

9. Harman states that "During prosecution of the '685 Patent, Davis knew that he had continued to use the Back Seat Driver with 50 subjects after he knew the invention would work." SUF, para. 58. Harman mischaracterizes my testimony on this point. I did not testify that 50 drivers used the Back Seat Driver after I "knew the invention would work." Also, the passage from my testimony relied upon by Harman was clarified a few moments later: "Q: Did you continue to use the working "Back Seat Driver" with other people around the Boston area between June of '89, which you say is when you knew it would work, and August of '89, when you signed your thesis paper? A: First of all, I think what I testified is that by June of '89, I was confident that the system would work.). Although the subjects drove a car equipped with the Back Seat Driver, the drivers were generally not shown how the Back Seat Driver worked. Their

exposure to the system was limited to entering a destination and driving the car according to the supplied directions.

10. I understand that Harman is claiming that I committed inequitable conduct or fraud on the Patent Office in obtaining my patent by withholding material information or making materially false statements to the Patent Office with an intent to deceive the Examiner. I understand that inventors and their attorneys are bound by a duty of good faith and candor in dealing with the Patent Office to be truthful and honest.

11. I believe that everything I said to the Patent Office was true, and that I gave the Patent Office the non-duplicative and relevant information that I had. I believe that everything in my thesis is true and is not misleading. I have never intended to deceive the Patent Office about my patent or any other patents, and I believe that I met or exceeded my duties to the Patent Office.

I swear under penalty of perjury that all of foregoing information is true today, and is consistent with sworn testimony I would have given during my deposition on February 16, 2006 if asked by counsel for Harman.

Dated: May 23, 2007

James R. Davis, Ph.D.

EXHIBIT 22

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF MASSACHUSETTS

MASSACHUSETTS INSTITUTE OF	)	
TECHNOLOGY,	)	
Plaintiff,	)	Civil Action
vs.	)	No. 05-10990 DPW
HARMAN INTERNATIONAL	)	
INDUSTRIES, INCORPORATED,	)	
Defendant.	)	

The videotaped deposition of PHILIP RITTMUELLER, called for examination, taken pursuant to the Federal Rules of Civil Procedure of the United States District Courts pertaining to the taking of depositions, taken before KRISTIN C. BRAJKOVICH, CSR No. 084-3810, a Certified Shorthand Reporter of said state, at Suite 5400, 200 East Randolph Street, Chicago, Illinois, on the 21st day of November, A.D. 2006, at 8:59 a.m.

COPY

PRESENT:

PROSKAUER ROSE, LLP,
(One International Place,
Boston Massachusetts 02110-2600,
617.526.9779) by:
MS. KIMBERLY A. MOTTLEY,
appeared on behalf of the Plaintiff;

KIRKLAND & ELLIS, LLP,
(200 East Randolph Drive, Suite 5400,
Chicago, Illinois 60601,
312.469.7019) by:
MR. JAMAL EDWARDS,
appeared on behalf of the Defendant.

ALSO PRESENT:
MR. JOE BURKE, Videographer,
Esquire Deposition Services

REPORTED BY: KRISTIN C. BRAJKOVICH, C.S.R.
CERTIFICATE NO. 084-3810.

THE VIDEOGRAPHER: We are going on the video record at 8:59 a.m. My name is Joe Burke, and I am a legal videographer with Esquire Deposition Services. Our address is 155 North Wacker Drive, Chicago, Illinois. The court reporter today is Kristin Brajkovich of Esquire Deposition Services.

Here begins the videotaped deposition of Philip Rittmueller taking place in Chicago, Illinois. Today's date is November 21, 2006. This deposition is being taken in the matter of Massachusetts Institute of Technology versus Harman International, et al., in the United States District Court, Northern District of Illinois, Eastern Division.

Will counsel please state their names for the record.

MR. EDWARDS: Jamal Edwards, counsel for Harman.

MS. MOTTLEY: Kimberly Mottley from Proskauer Rose, counsel for MIT and the witness.

THE VIDEOGRAPHER: Will the reporter now swear in the witness, please.

(WHEREUPON, the witness was duly sworn.)

Q. Do you think Jim Davis understood that?
A. Uh-huh.
Q. Did you-all discuss that?
A. I don't recall.
Q. Do you recall how long it took for them to get the database and put it in the car?
A. No, I don't.
Q. Do you recall ever seeing the database -- strike that.
Do you recall ever seeing the Back Seat Driver function with the database in the car?
A. I don't remember that.
Q. When did you first see Jim Davis' thesis?
A. I got it sometime after it was out and I visited MIT.
Q. "Sometime after it was out," what do you mean by that?
A. Well, when it was -- after it was available.
Q. After it was available to whom?
A. After he finished it.
Q. Did you ever see it before he finished it?

A. No.
Q. Did you ever see drafts of the thesis before he finished it?
A. I don't recall. I don't believe so.
Q. Do you recall discussing the thesis with anybody before he finished it?
A. No.
Q. Were you aware that he was doing a thesis?
A. Oh, yeah. It is for his Ph.D.
Q. Were you aware of what the thesis was about?
A. Yeah.
Q. Did you see any presentations about the thesis?
A. No. I mean, not the thesis per se. We had -- we were monitoring the project and we had quarterly reports and so on like that but not the thesis per se.
Q. During those quarterly reports, were there any discussions about the thesis?
A. No, not that I recall.
Q. Do you recall being told anything about the status of the thesis during the quarterly

A. Yes, sir.

Q. Do you recall receiving this document?

A. Yes.

Q. Do you see the date on the document as 31 July 1989?

A. I see the date on the document.

Q. Do you have any reason to believe that you did not receive this document on that date?

A. I did not receive it then.

Q. Do you recall when you received it?

A. I received it sometime after.

Q. Sometime after? How much later?

A. I don't know exactly. It was probably sometime in the fall after the thesis had been completed. When this one was written, the thesis wasn't completed. This is the final report.

Q. Uh-huh. And did you receive the quarterly reports after the thesis was completed?

MS. MOTTLEY: Objection, vague as to which quarterly reports.

BY MR. EDWARDS:

Q. Any of them, including -- let's start with Rittmueller 7, which is the Back Seat Driver, Quarterly Report, dated March 5, 1990.

You received that one after the thesis was completed?

A. I don't know when I received them.

Q. What was the -- do you recall the procedure for MIT's transmission of these quarterly reports?

MS. MOTTLEY: Objection, assumes facts not in evidence.

BY THE WITNESS:

A. No, I don't remember the method.

BY MR. EDWARDS:

Q. Do you recall if there was a procedure?

A. I don't know that there was a procedure.

THE VIDEOGRAPHER: I need to change tapes in a minute.

MR. EDWARDS: Take a break.

MS. MOTTLEY: Sure.

THE VIDEOGRAPHER: Off the video record at 11:50.

(WHEREUPON, a recess was had.)

THE VIDEOGRAPHER: We are back on the video record at 11:58 with Tape No. 3.

BY MR. EDWARDS:

Q. Before we broke, we were talking about

Rittmueller 9 or RITT 9 which is the Back Seat Driver report dated July 31, 1989. Do you have that in front of you?

A. Yes, sir.

Q. I believe it was your testimony that you received this report after the thesis was submitted; is that correct?

A. It was all put together like this.

Q. Are you sure about that?

A. Positive.

Q. Do you see on -- since we combined the thesis with this paper, do you see the thesis which begins on Rittmueller 187?

A. Yes.

Q. Do you see it is not signed by the author?

A. Yes.

Q. Do you see that it is not signed by the chair of the department?

A. Yes.

Q. Do you see that the only signature on the document dated September 1989 is that of Nicholas Negroponte?

A. Yes.

Q. Do you understand that after Mr. Davis completed his thesis, that he signed it?

A. I would assume so.

Q. Do you understand that the copy that was made available to the public in the library was signed by Mr. Davis?

A. I don't know that.

Q. Have you ever seen a copy of the thesis that is available through MIT's library?

A. No.

Q. Have you ever seen a copy that was signed by Mr. Davis?

A. No.

Q. Are you sure you got this after Mr. Davis submitted the thesis?

A. I'm almost -- I'm sure I got this after he submitted the thesis.

Q. Do you have any idea why he didn't sign it?

A. No.

Q. And how are you sure that you got this after the thesis?

A. I just remember that it was -- I was there, and there was talk about it being in the

library or being wherever it goes to someplace, shelving it or whatever they call it, and I asked to see if I could get a copy at that particular time and I got this one.

Q. Would it surprise you to know that the copy that is in the library has Jim Davis' signature on it?

A. No. I would assume it would.

Q. But you would agree with me the copy that you have, doesn't have --

A. Does not have it, correct.

Q. So you would agree with me, they did not get you a copy of what was on the shelf at the library?

A. Yes, they did not.

Q. And do you recall now whether it was NEC and MIT's practice to exchange these quarterly reports after the thesis had been completed?

A. There was not specific timing set up for quarterly reports. They maybe happened at visits. I mean, they had to prepare them, but as far as exchanging them, there was not specific timing set up.

Q. You understand that you are testifying

today under oath?

A. Yes, sir.

Q. And do you understand that if we find inaccuracies later, we will point them out at trial if you are subpoenaed to testify at trial?

A. I understand that.

Q. Do you understand that testifying falsely under oath is a crime called perjury?

A. I understand that.

Q. And it is your testimony today that you did not receive this until after the thesis was submitted to the library?

A. Yes, that's my recollection.

Q. And do you recall receiving any other copies of this final report prior to the thesis being submitted?

A. I don't recall any other.

Q. Do you recall receiving any other copies of Mr. Davis' thesis prior to it being submitted to the library?

A. No.

Q. Let's look at the quarterly report on page -- the second page, which is Rittmueller 173.

A. Yes.

with MIT?
A. No, I don't.
Q. Do you recall having any discussions with MIT concerning the confidentiality of the Back Seat Driver?
A. Not -- I mean, typically -- typically, shared research is held, I'll say, close to the vest.
Q. What does "close to the vest" mean?
A. Well, you don't go out and tell a whole bunch of people or tell people about it. You keep it within the company, and MIT keeps it within MIT.
Q. Did you have any documentation memorializing that understanding?
A. Nope.
Q. And in the case of work -- joint work being developed between NEC and other parties, did you ever execute confidentiality agreements?
A. Only if it is like a third-party company or a consulting firm or something like that.
Q. You would agree that MIT is a third party?
A. Yes, but we don't have nondisclosures with our outside patent counsel or our law firm or

our accountants and so on. That is given. You understand that.

Q. Right. But you would agree that MIT is not a law firm?

A. That's correct.

Q. MIT is an educational institution?

A. Yes.

Q. Do you understand the general policy of educational institutions, which is to make the information available to the public?

MS. MOTTLEY: Objection to the characterization and calls for speculation.

BY MR. EDWARDS:

Q. Would you disagree that educational institutions like MIT typically make their information available to the public?

MS. MOTTLEY: Objection, vague.

You can answer.

BY THE WITNESS:

A. Well, that is one of the things they do, but they also end up having DARPA contracts and they also end up having directed research projects, and there is a continuum of confidentiality, if that's what you're talking about.

BY MR. EDWARDS:
Q. And if there was such confidentiality, it would be in the contract, wouldn't it?
A. Not necessarily.
Q. If, for example, NEC decided to disclose information MIT thought was confidential, what do you believe MIT would have been able to do about it without an agreement?
MS. MOTTLEY: Objection, hypothetical, calls for speculation.
You can answer.
BY THE WITNESS:
A. Repeat the question again.
BY MR. EDWARDS:
Q. Let's take it in chunks. You agree that you have already testified that you did not have, on behalf of NEC, a confidentiality agreement?
A. I don't recall one, and I don't believe I ever executed one.
Q. With MIT?
A. Correct.
Q. Do you understand -- strike that.
Did you have any understanding that the information that you were receiving from MIT was

confidential?

MS. MOTTLEY: Objection, vague.

BY THE WITNESS:

A. Confidential -- confidential-ish, closely held-ish, that's how we considered it.

BY MR. EDWARDS:

Q. But not confidential?

MS. MOTTLEY: Objection.

BY THE WITNESS:

A. Not as described in things like protective orders.

BY MR. EDWARDS:

Q. Or as described in things like confidentiality agreements that two parties sign?

A. Correct.

Q. If you had decided to share MIT's information with a third party, do you believe that MIT would have had any recourse against NEC?

A. Any direct recourse?

Q. Yeah.

A. Probably not.

Q. So you would agree that you were -- would have been within your rights to share the information with third parties?

CORRECTIONS TO DEPOSITION TRANSCRIPT
OF PHILIP H. RITTMUELLER
November 21, 2006

MASSACHUSETTS INSTITUTE OF TECHNOLOGY V. HARMAN INTERNATIONAL INDUSTRIES INC., C.A. NO. 05-10990-DPW

Page	Line	Change/Correction	Reason
2	8	Add "and the witness" after "Plaintiff"	Transcription error
21	3	Change "not to answer. To" to "not to answer, to"	Transcription error
84	19	Add the word "you" after "Does that satisfy"	Transcription error
101	22	Change "facts" to "fax"	Transcription error
137	19	Delete the words "like that"	Transcription error
153	21	Change "them" to "then"	Transcription error
207	8	Add "and the witness" after "Plaintiff"	Transcription error
210	1	Change "Front is Piece" to "Frontispiece"	Transcription error
226	11	Change "to" to "through"	Transcription error
227	17	Change "Widener" to "Weidemier"	Transcription error

I have read the foregoing transcript of my deposition and except for the corrections and changes noted above, I hereby subscribe to the transcript as an accurate reflection of the statements made by me.

Philip H. Rittmueller

Philip H. Rittmueller

Jan 8, 2007

EXHIBIT 23

TO BE FILED UNDER SEAL

PURSUANT TO MIT'S ASSENTED-TO MOTION TO FILE UNDER SEAL (DOCKET NO. 158)

EXHIBIT 24

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF MASSACHUSETTS

MASSACHUSETTS INSTITUTE OF TECHNOLOGY, Plaintiff, v. HARMAN INTERNATIONAL INDUSTRIES, INCORPORATED, Defendant.	Civil Action No.: 05-10990 DPW Magistrate Judge Judith G. Dein

DECLARATION OF CHRISTOPHER M. SCHMANDT

I, Christopher M. Schmandt, state the following:

1. I am a named inventor on U.S. Patent No. 5,177,685, which is being asserted against Harman in this case.

2. I was an advisor of Dr. James R. Davis during the "Back Seat Driver" doctoral research. I currently am Principal Research Scientist at the MIT Media Lab.

3. Harman's Statement of Undisputed Facts ("SOUF") says "Schmandt testified that while Davis was working on his thesis, and even after he finished drafting it, Davis 'could print a copy [of it] whenever he wanted and give that to anybody that he wanted to.'" SOUF ¶ 5. However, Harman has mischaracterized my testimony by omitting clarifying answers that I gave in response to Harman's questions. See MIT 30(b)(6) deposition at 115:14-23 (Q: So you didn't mean to imply that the thesis was on a password protected computer in the Media Lab, that that excluded the possibility that anybody printed out and shared copies of the thesis? A: That limits the number of people who could print out and share copies of the thesis to approximately two. Q: How does it do that? A: Jim Davis and myself are the only ones who had access to the document); 116:23-117:7 (Q: Is there any other evidence that M.I.T. contends supports any steps that were taken to preserve the confidentiality of Mr. Davis' thesis paper or drafts thereof during the time period prior to August 9th of 1989? A: It's generally University policy, and M.I.T. is no exception, that drafts of documents such as thesis are not public. They are not to be distributed publicly).

4. The computer on which drafts of Jim's thesis were on a password-protected computer in a locked room accessible by a keypad with an entry code. MIT 30(b)(6) deposition at 113:15-21.

5. Harman says that "On July 31, 1989, Davis and Schmandt sent a copy of the completed thesis ('certified by Nicholas P. Negroponte,' the then Director of the MIT Media Lab) to a Mr.

Rittmueller, an NEC employee at the time." SOUF ¶ 6. I do not recall sending a copy of Jim's completed thesis to Phil Rittmueller on July 31, 1989 (or any time before August 9, 1989). I believe that Phil did not get a copy of Jim's thesis until after it was shelved in MIT's library.

6. Harman says "The copy of Davis' thesis sent to Rittmueller was not marked confidential in any way." SOUF ¶ 7. However, NEC was the sponsor of the Back Seat Driver research and as such, entitled to periodic reports on the progress of the research. NEC was also a licensee of this technology as a result of the sponsorship, and MIT and NEC understood that the underlying research work and internal document drafts were not publicly available and not to be distributed until the documents, like Jim's thesis, were finalized.

7. Harman says "By May 26, 1989, Davis was prepared to defend his thesis and invited the public to attend." SOUF ¶ 12. Jim actually defended his thesis in late summer of 1989, and he graduated in September 1989. While I do not remember the exact room in which the thesis defense took place, I do remember that the thesis defense did not take place in the room identified on the draft flyer, namely E15-283a of the Media Lab, because Jim defended his thesis in a larger room.

8. Harman says that "MIT had a policy forbidding secrecy and encouraging the free sharing of information in 1989." SOUF ¶ 13. MIT's policy does not absolutely forbid secrecy and encourage sharing of information before the information is ready to be shared. As an academic institution, MIT has ethical and integrity reasons for not publishing research or other findings before the information is finalized or verified. Until the thesis was shelved in the MIT library, the general public did not have access to Jim's thesis.

9. Harman says that "NEC was upset and unhappy that MIT's publicity of the Back Seat Driver had caused NEC to waste considerable time and effort only to lose any foreign patent

rights it may have had." SOUF ¶ 18. In fact, NEC was not upset and unhappy with MIT. NEC continued to sponsor the MIT Media Lab after the Back Seat Driver project was completed, and Phil Rittmueller continued to support the Media Lab's research.

10. In addition to the patent in this case, I am a named inventor on three other issued U.S. Patents and seven U.S. Patent applications. I understand that as an inventor I have a duty of candor and good faith in practice before the U.S. Patent Office, and that this duty requires me to provide relevant, non-cumulative information that is known to me to the Patent Examiner. In all of my patents and applications, I strive to meet or exceed these duties.

11. I understand that violations of the duty of candor and good faith can result in one or more of my patents or applications being unenforceable. I understand for someone to prove that one of my patents or applications is unenforceable, that person is required to prove that I withheld material information from the Patent Office or made material false statements to the Patent Office with an intent to deceive the Patent Office.

12. As an MIT research scientist and graduate student advisor, I am bound by strict ethical obligations relating to academic research, including not publishing someone else's work, not accepting a doctoral thesis that is not original and significant, and to generally be honest in stating research results or discoveries.

13. At no time during the prosecution of the '685 patent did I withhold information from my patent attorney, Bo Pasternack, or from the Patent Office that I thought was relevant to the patented invention. Additionally, if any information that is deemed to be relevant was withheld by me, I did not withhold that information with intent to deceive the Patent Office.

I swear under penalty of perjury that all of foregoing information is true today, and is consistent with sworn testimony I would have given during my deposition on February 8 and May 19, 2006 if asked by counsel for Harman.

Dated: May 23, 2007

Christopher M. Schmandt

EXHIBIT 25

Direction Assistance

James Raymond Davis
and
Thomas Frank Trobaugh

December 1987

Speech Research Group Technical Memo 1
The Media Laboratory
Massachusetts Institute of Technology

Abstract

Direction Assistance is an interactive program that provides spoken directions for automobile travel within the Boston area. The program has a telephone interface which uses touch tone keypad input and synthetic speech output. Routes are both short and easily followed. The directions are given in fluent English. The program has successfully directed newcomers through Boston.

This paper tells how we built Direction Assistance, with emphasis on how the available databases are and are not useful for this application. It also talks about automatic generation of route descriptions, and compares our work to that of others.

1 Introduction

1.1 Overview

Direction Assistance consists of about 11,000 lines of CommonLisp code, runs on a Symbolics Lisp Machine, and uses a Digital Equipment Corporation DecTalk synthesizer. It was written mostly during the summer of 1985 at the Thinking Machines Corporation of Cambridge, Mass. Since then, it has undergone periodic rewrites. It is running at the Media Lab, and is also installed at the Computer Museum in Boston and as part of the Age of Intelligent Machines exhibit traveling across the United States.

Direction Assistance consists of five modules. The Location Finder queries the user to obtain the origin and destination of the route. A location may be specified as a street address or as a telephone number. The Route Finder finds a simple, short route between the two points. The Describer generates high quality English text describing the route. The Narrator recites the route to the user. In addition, there is a graphical interface for maintenance.

These modules share a set of databases. The most important is the street map, which covers an eleven square mile area of Boston centered on the Charles River. A second database is an inverted phone directory, which provides a street address for a phone number.

In this paper, we discuss the databases, the Route Finder, and the Describer. The Location Finder and Narrator are described in [2].

It would be inappropriate to continue without mentioning the pioneering work of Jane Elliot and Mike Lesk[5,4]. Our work differs from theirs in several ways. Our interface uses synthetic speech and pushbutton telephones rather than a graphics terminal. We are much more concerned with generating fluent English text than they. On the other hand, we are not much concerned with route finding algorithms. Finally, Elliot and Lesk used a Yellow Pages database in addition to the white pages and street map. We will not clutter this paper with citations to Elliot and Lesk on every point where they have made contributions. They are to be assumed.

The New Yorker, April 6 1987 p 56

We next discuss the underlying databases, and then the modules which use them. The description of the databases will by necessity refer to features of the program in order to motivate the construction of the database.

2 Databases

2.1 Streets

Our street map began as a DIME (Dual Independent Map Encoding) file distributed by the United States Geological Survey[1]. A DIME file consists of a set of straight line segments, each with a name, a type, endpoints in longitude and latitude, and some additional information. Segment types include natural features (chiefly water boundaries), railroads, town and property lines as well as streets. The latter are also labeled with address numbers on both sides of the street at each endpoint; thus is is possible to estimate the coordinates for any street address by interpolation, assuming all lot sizes to be constant.

We began with an 11 square mile subset centered roughly on the Charles River. This includes portions of Boston (Charlestown, Allston, Back Bay, South End, North End), Brookline, and Cambridge (Cambridgeport and Harvard, Inman, Central and Kendall Squares). (See figure 1.) There are about 279 miles of streets in the map, which contains 6163 segments, of which 5506 correspond to streets. The total size is about 477 kilobytes.

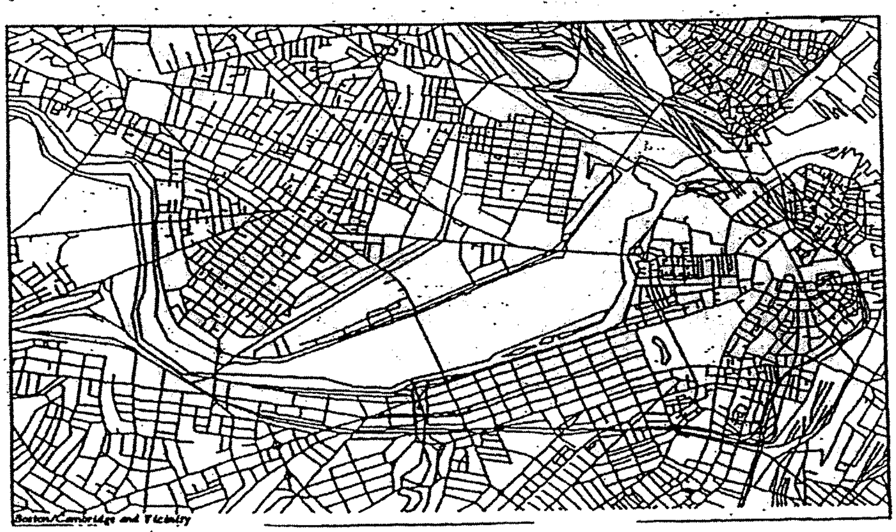


Figure 1: Street Database

The DIME file as supplied was far from suitable for our use. It contained many errors: streets were missing, mislabeled, or misconnected, and names were not spelled consistently. In some cases, more than one segment occupied the same place, and some segments were connected to themselves. We wrote a

battery of plausibility checkers to detect and remove these errors, automatically where possible.

In addition to correcting errors, we had to add new kinds of information to the database. The most important information was whether a street was one way. We also classified streets by quality, and recorded textual descriptions for some turns. We'll now describe each of these.

Segments in the DIME file are deemed to connect if they share a common endpoint. We refer to this kind of connection as ***physical connectivity***. Every segment has two endpoints, and for each of these there is a list of the segments which are physically connected to that endpoint. Obviously, physical connectivity is a symmetric non-reflexive relation. Physical connectivity is not sufficient for route finding, since it may not be legal to drive from one piece of pavement to another, even though they meet, because one might be one-way, or a turn might be forbidden, or there might be a divider in the way[1]. To provide for the fact that one can not always drive from a segment to any other physically connected to it, we added a second kind of connection, ***legal connectivity***. Two (street) segments are legally connected if one may drive from one segment to the other without breaking a law. Legal connectivity supplements, but does not replace, physical connectivity. Physically connected segments include those that can be seen in passing, and must also be retained, for they are important in forming descriptions. One cannot turn onto a railway, though the street and railroad segments are physically connected, but one may also wish to mention the crossing of the railroad as a salient detail of the tour.

Not all streets are created equal. We wanted our routes to use the widest, fastest, and most easily located streets, so we gave each street a value for goodness (super, good, average, or bad). By definition, most streets are average. The super streets are the expressways, interstate highways, and other limited access roads. Our rating of super is awarded more on the basis of being easy to find and to follow, since super roads are often crowded and slow. At the other extreme, the bad streets are those we know to be narrow or in poor repair. Our database contains only three miles of such streets. Unlike the taxi driver, we are not interested in shortcuts which use marginal streets.

The concept of "better than average" is a bit hard to define. We wanted to identify streets which were likely to be easy to find and follow. We decided that streets that were long were likely to be important, so we marked all streets longer than one half mile as "good", and then added a few more by hand if they seemed important. The resulting network is about 105 miles long, and forms a simplified skeleton covering our map. It appears in figure 2.

The third extension was to expand the street classification scheme. We added new segment types for bridges, underpasses, rotaries, and access ramps. This information is useful to both the route finder and to the describer, as we show below.

Finally, at every intersection in the map we can store additional descriptive information about each possible turn at the intersection, in the form of labelled items. Each item has a label telling what kind of information is stored, for instance an exit number or the text of a sign present at that intersection. This information is used by the Describer.

We made almost all of these corrections and augmentations ourselves from observations in the field.

[1]In this case, the turn is forbidden by physical obstacles, and not merely law or custom. But rather than engage in an epistemology of barriers, we use the same mechanism to represent this restriction.

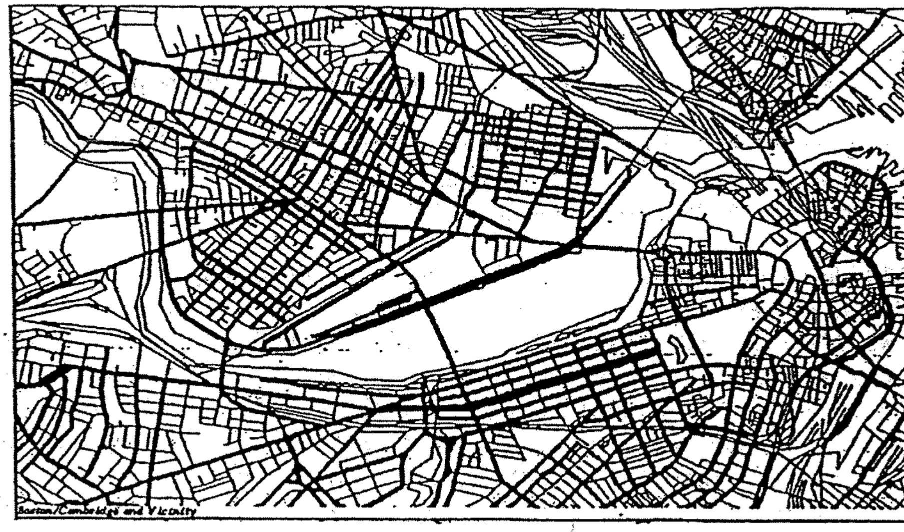


Figure 2: Network of good streets

We could not find a paper map listing all the one way and restricted turning streets of Boston, so we had to drive around looking for them. This investment in time and effort is a major cost of the system, but needs to be done only once. The graphic database editor was extremely useful, as it permitted rapid editing of the database. We commend the many designers of the Lisp Machine window system for making this easy.

2.2 Neighborhoods

A related database lists the neighborhoods of Boston, with their associated zip codes. We need this database because a given street might occur in several different towns. For instance, there are three distinct streets named "Washington" in our map, in Boston, Cambridge, and Somerville. Even worse, Cambridge contains two different streets named "Elm".

The Location Finder uses this database to disambiguate street names. When the user supplies a name that could designate more than one street, it is necessary to ask for further information, e.g. "Do you mean Beacon Street in Cambridge or in Boston?". To make this as easy as possible, it is best to use the names of the most general locations that still distinguish the streets[2]. If the street occurs in two neighborhoods of the same city, the neighborhood name is used. If the street occurs in different cities, the city name is sufficient. We determine neighborhood from the Zip code of the street. The mapping from Zip to neighborhood is imperfect, but good enough for our purposes. For the most part, the neighborhood names are those used by the local post offices. We think it is very likely that these names are also familiar to the local residents, and intelligible to visitors, but we have no evidence.

[2]This assumption could be tested. If people represent locales hierarchically, and if there is a preferred level of representation, it might be *more* difficult to determine inclusion in a too-general region.

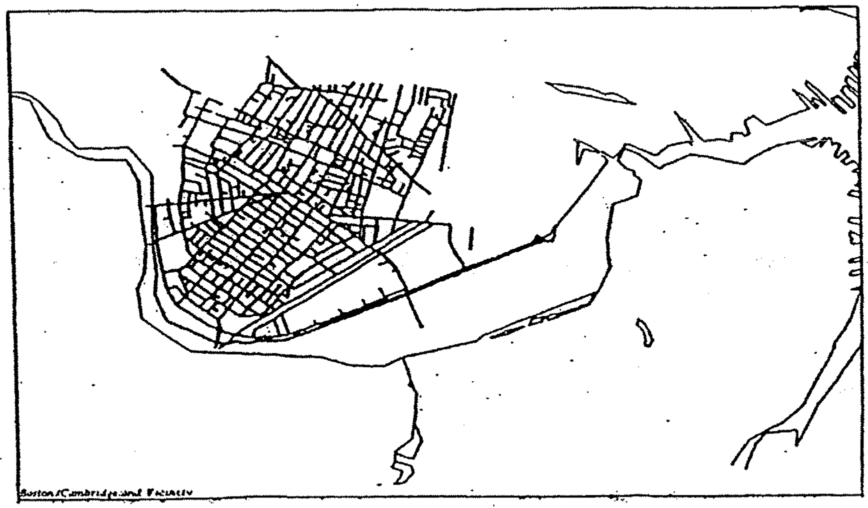


Figure 3: Central Square, 02139

2.3 Inverted Phonebook

The inverted telephone directory allows us to map telephone numbers to street addresses. We built this database ourselves, by inverting a "white pages" database. This required parsing the street addresses in the white pages. which was difficult for several reasons. The white pages have a great variety of spelling and abbreviation. We found, for instance, 23 variations of "Massachusetts". In addition, the format is not consistent. Sometimes listings contain professions ("atty" or "archt"), or a second phone number ("If No Answer"), or other information (e.g. "toll free", "children's phone"). We did not have the typographic information that helps separate names from locations and phone numbers. Finally, addresses are often incomplete, listing only a city, or road, or some a name which does not correspond to a street, such as a shopping center or an office park.

Even after parsing, it can be hard to determine locations from a a phone book listing. Even the best entries have at best a street, number, and city. But as we said above, streets occur in more than one place within a city. There is a rough correspondence between exchange and locale, so we can sometimes determine a unique location with this extra information. But when we can not, the Location Finder must ask the user to choose a location, as it does for street names.

Having described the databases, we now turn to the modules of Direction Assistance.

3 Route Finder

The Route Finder finds a route subject to three constraints. The route must be easy to follow, reasonably short, and it must be found before the user loses patience[3]. These constraints conflict. Rarely is there a straight line route - the shortest route may require devious shortcuts. We are biased towards simplicity, since we want our users not to get lost.

The output of the Route Finder is a *path*, an ordered list of street segments, such that the origin is on the first segment, the destination on the last, and each segment is legally connected to the next. The real time requirements of the system rule out exhaustive, breadth first search[4]. The current implementation uses a best first search that provides reasonably good routes in a moderate time. A sample route appears in figure 4.

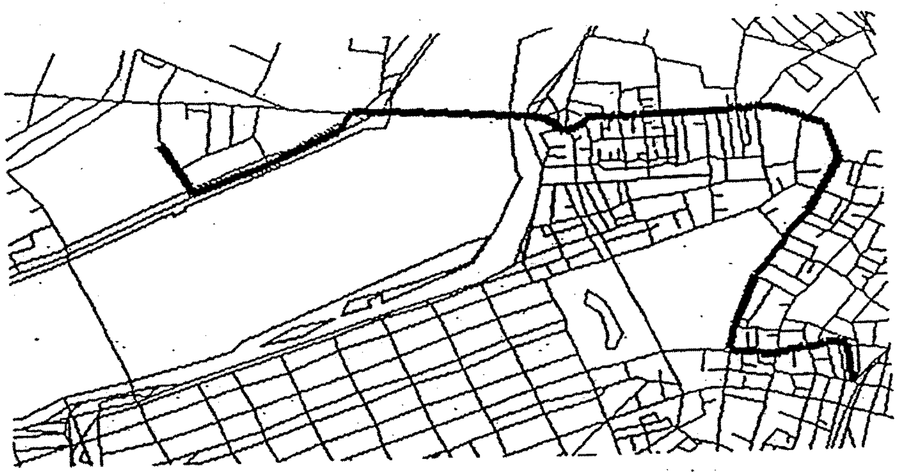


Figure 4: A sample route

Best first search is an improvement on breadth first search. Search is conducted in (simulated) parallel on a list of candidate partial paths. For each path, there is a cost which is the sum of the known cost for the current path and an estimate which is a lower bound on the cost for (as yet undetermined) remainder of the path. At each step of the search, we consider the path of least cost, and expand it by considering all segments legally connected to its terminal end. The estimation function is just the Cartesian distance, since no route can be shorter than a straight line. Figure 5 shows every segment visited by the search in finding the route shown above.

As Elliot and Lesk point out, it is not desirable to find minimum distance routes, for these have too

[3]A fourth constraint which we do not consider explicitly is that the route must be easy to describe. We are familiar with situations where a person asks for a route to a familiar place, but we can not describe the route because it is a "felt path": we no longer remember (or do not know) the names of the streets, only a list of subtle cues we can't describe.

[4]on a serial machine, anyway. An experimental version on the Connection Machine[6] works in just this way.

Figure 5: All segments touched by search

many turns. Such routes are hard to describe and hard to follow. Elliot and Lesk impose a cost of 1/8 mile for a right turn, and 1/4 mile for a left turn. We extend their system of costs in several ways. First, we consider street goodness. Travel down a "super" street is not as "expensive" as travel down an average street, and travel down a "bad" street incurs a surcharge. Second, we consider sharp right turns to be as bad as left turns, since they are harder to execute. Third, we reduce or waive turn costs in some cases. For example the turning cost is halved for a turn on to or off a one-way street, and waived altogether for a forced turn ("left turn only"). A turn onto a bridge is also free, since bridges are major landmarks, and contribute to ease of following the route. We have not studied the effect of these routes on the routes found, nor have we attempted to determine whether the routes are better where different. Such a study would require a model of driver's errors, both of understanding and of execution.

4 Describer

The Describer generates a set of text instructions for following the route. (An example of its output appears in figure 6.) We generate text instead of a map for two reasons. First, the system is used by telephone, which limits the output to voice. But even if our users had portable graphics terminals with modems, we would prefer text to graphics, because some people can not read maps. In a survey of map reading abilities Streeter and Vitello recommend text as a "lowest common denominator" [9].

The Describer creates a new representation of the route, instead of using the path itself. There are two reasons for this second form of representation. First, the elements of a a path (segments) are too fine grained for useful textual description. Recall that a segment reaches from just one intersection to the next. This is smaller than our sense of a "street", which continues as a unity past many intersections. In addition, segments are straight lines: so a street with no intersections might be still represented as a

```
If your car is on the same side of the street as 20 Ames Street, turn around, and start
driving. Drive all the way to the end, about one eighth of a mile. Make a left onto
Memorial Drive. Drive about one eighth of a mile. After you pass Wadsworth Street on
the left, take the next left. It's an easy left. Merge with Main Street. Stay on Main
Street for about ninety yards, and cross the Longfellow Bridge. You'll come to a
rotary. Go about half way around it, and turn onto Cambridge Street. Drive all the way
to the end, about three quarters of a mile. Make a right onto Tremont Street. Drive
about one half of a mile. After you pass Avery Street on the left, take the next left
onto Boylston Street. Stay on Boylston Street for about one eighth of a mile. After
you cross Washington Street, it becomes Essex Street. Keep going. Drive about one
eighth of a mile. After you pass Ping On Street on the right, take the next right onto Ed-
inboro Street. Number 33 is about one eighth of a mile down on your right side.
```

Figure 6: sample of directions

sequence of segments if it made a broad turn. We want to describe the entire stretch of a street as a single object. A second reason is that a path is just a topological structure, but natural instructions should be expressed in terms of geometry and of types of streets. Consider the difference between a "fork", a "T", and an "exit", as shown in figure 7. All have the same topology - a branch in the road. But they must be described differently. The Describer's structure is a *tour*, which is a sequence of *acts* to be taken in following the path.

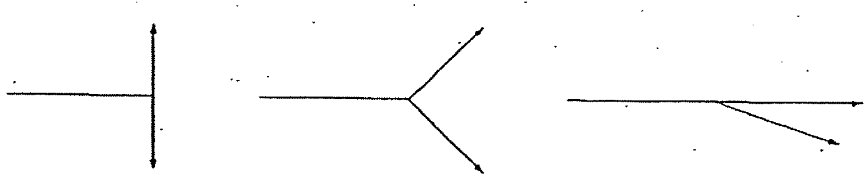


Figure 7: T, fork, and exit all have same topology

4.1 Acts

Acts are things a driver does (or notices) while following a route. Figure 8 shows our taxonomy of acts.

Each of these acts must be *recognized*. The route finder works only with segments, and the Describer builds acts which describe motion from segment to segment. We now describe each of these acts, and how we recognize them. We describe the text generated for each below.

- Boundaries
  - Start
  - Stop
- Straight
  - Name Change
- Turn
  - Enter
  - Exit
  - Merge
  - Fork
  - U Turn
  - Rotary
  - Ordinary

Figure 8: Act Taxonomy

The first act is necessarily START, and the last STOP. They are trivial to recognize. The NAME CHANGE act requires the driver to notice a change in name, but nothing further. We include it only to avoid confusion. The difference betweeb a NAME CHANGE and a TURN is that the former consists of a two streets meet within 10 degrees of straight, and where there is no other segment at the intersection with the same name as either of them. These two criterion are almost correct, but not quite right. There are streets which seem (to us) to be name changes, but have more extreme turns (at least, as represented in the map). For the present, we have caused these to be treated as name changes by changing the map, slightly altering the positions to make the turns more gentle. This would be intolerable were we using the map for, say, surveying, but is of no consequence for route description.

There are several types of TURN acts. The ENTER and EXIT acts refer to limited access roads. In this case, some of the travel will often be on "nameless" segments - access ramps. This shows one reason for the additional classification of street segments. We want to recognize entrances and exits, and we want to describe access ramps in different terms than other streets.

A MERGE and a FORK are similar in that they are different actions that might be taken at the same intersection, depending upon the direction one is driving. A Merge has the following characteristics:

1. Old and new streets have different names.
2. Only one street is legally possible.

3. The angle of turning is small.
4. There is at least one other street going to the destination street.
5. All streets make only small turns onto the destination.

At a FORK on the other hand, there are at least two ways to go, though all are shallow turns. Note that a "fork" onto an exit ramp is recognized as an EXIT.

There are two types of U turn known to drivers in Boston. The first kind is made in the middle of the street (within a single segment, in our representation). Our routes never include such turns. Not only are they illegal, such moves never shorten the path. The second kind of U turn is the sort one makes to reverse direction on a divided road. Typically one makes a left onto a nameless piece of road, which is often very short, and then makes a second left. This double turn is what we call a U TURN act. It is very important to recognize this act, because describing it as two successive lefts is very confusing. It is a single entity in the minds of drivers. We recognize a U TURN as a pair of turns where the intermediate segment is less than 165 yards long, the total angle is within 20 degrees of 180, and the name of the street is unchanged after the two turns.

Perhaps the most insidious feature of Boston's streets is the ROTARY. For those not familiar with the term, a rotary is a one way street in a circle. Traffic enters the rotary on roads which are (usually) tangent to the circle, moves counterclockwise around the circumference, and exits on another tangent. Rotaries are difficult to traverse because they cars enter and exit within a very short distance, without much room to maneuver. Recognition of a rotary is trivial, but only because we label all rotary segments explicitly in the street map.

An ORDINARY turn is anything not handled by one of the above cases.

4.2 Cues

While the Describer is collecting the acts of the tour, it also collects cues. A cue helps the driver follow the tour. We distinguish four kinds of cues. *Action* cues tell when to do an act. *Confirmatory* cues describe things that will be seen while following the route. *Warning* cues caution the driver about possible mistakes. A warning successfully heeded also serves as a confirmatory cue. *Failure* cues describe the consequences of missing an act, e.g. "If you see this, you have gone too far".

The most common action cue is just the name of the street. An instruction such as "Turn right onto Tremont Street." tells the driver what to do and when to do it. This cue may be hard to follow, since street signs may be missing. A very strong action cue is coming to the end of a road. No one is likely to forget to turn under this circumstance, since the alternative is to leave the road. We refer to this as a "forced turn" cue.

Distance traveled is also a cue, but hard to use. People have a vague sense of distance, but not an accurate one. Still, we use distance as a secondary cue, because we can compute it easily and it helps some people. We express distance in yards when less than 1/16 of a mile, and other distances in approximate

fractions of a mile because people are accustomed to seeing distances expressed this way. We do not use tenths of miles, because some people do not know how to use odometers, and because using an odometer to calculate distance requires doing mental arithmetic, which might prove distracting while driving.

We never use blocks, since a block is not a clearly defined concept. We do not know whether a block is bounded by an intersecting street, or only by streets that cross and continue. Figure 9 illustrates this. In

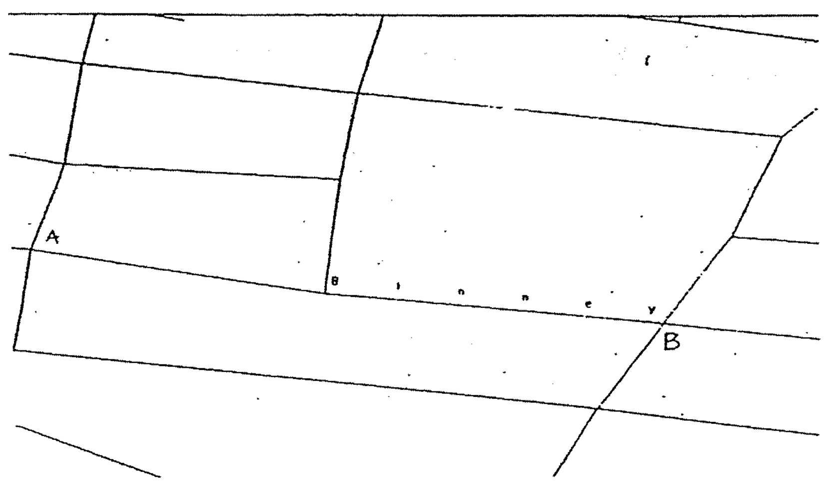


Figure 9: Is the distance between "A" and "B" one block, or two?

any event, we do not expect our drivers to be able to drive more than two or three blocks without losing count. Since we don't want to rely on distance or counting blocks, we use as a cue for an act the name of a street immediately preceding the act. This is a risky cue, since the driver who misses the cue may keep looking for it and miss the destination street as well. To make this less likely, we use only streets on the same side as the turn for a cue. This way, a driver need attend to only one side of the road while looking for street signs, so if the cue street is missed, the target street may still be seen. This same strategy is adopted in [10].

The confirmatory cues are crossing major streets or railroads, or going through an underpass. The only warning cue currently is a warning about left exits from limited access roads. We assume drivers will not take the wrong exit, but if they keep in the left lane they may be surprised by an unexpected left exit. We have not implemented failure cues.

4.3 Generating Text

For each act there is a corresponding routine which generates one to three sentences describing it. The routine selects appropriate cues from all those gathered. Now we'll describe some aspects of generating text.

```
(defun disc-seg-rotary (act)
  (list
    (make-sentence
      "You'll" "come" "to"
      (make-np-constituent '("rotary") :article :indefinite))
   (make-conjunction-sentence
     (make-sentence
       "Go" (rotary-angle-amount (get-info act 'rotary-angle))
       "way" "around" (make-anaphora nil "it"))
     (make-sentence
       "turn" "onto" (make-street-constituent (move-to-segment act) act)))))

(defun rotary-angle (angle)
  (selector angle <=
    (45 '("just" "a" "little"))
    (135 '("about" "a" "quarter"))
    (225 '("about" "half"))
    (315 '("about" "three" "quarters" "of" "the"))
    (360 '("almost" "all" "the"))))
```

Figure 10: Generator for rotary

Generating text for a START is tricky because it is hard to specify an initial direction. We do not use absolute directions, because most people do not know them. If we had a landmark database we might sometimes use relative direction (e.g. "towards the river"). Instead, we use the initial address, since that also determines a side of the street, and thus a direction to drive. We might have used "If your car is on the same side of the street as ... start driving the way it is facing.", but that sounded clumsy. Instead, we chose to give a negative instruction, either "If your car is on the same/opposite side of the street from ... turn around, and start driving." For one way streets we mention that the street is one way, and say "just start driving." We think (but do not know) that drivers would not have confidence in the instruction ("just start driving.") if it did not indicate that the system knew about the one way street.

One of the simplest generators is for rotaries. It appears in figure 10. Rotaries are hard to describe and hard to follow, because there are no good references for distance around a rotary. We can not expect people to measure angular distance around the rotary, and there may not be signs. The segments of a rotaries may or may not be nameless, or there may be several names involved. The rotary itself may have a name, e.g. Leverett Circle, but this name does not appear in the database and usually does not appear on any street signs either.

Output from this generator appears in figure 6. The generator produces two sentences, the second of which is a conjunction of two sentences. The distance around the rotary is converterted from an absolute angle, as measured on the map, to an approximation in English.

The instructions generated have syntactic structure only for sake of exploiting generality in text generation. Thus the function `make-np-constituent` handles agreement between the article and the noun. The function `make-sentence` ensures that capitalization and punctuation are correct. Text is sent directly to the synthesizer, and punctuation is required to achieve proper intonation. The function `make-anaphora` serves no purpose at present, but in planned future research will allow us to convey intonational features of discourse[3].

4.4 Comparison

We can compare our descriptions with those generated by Streeter and colleagues[10].

Streeter's descriptions are intended to be understood and acted upon in real time, as if uttered by a navigator in the next seat. (In fact, they are recorded on a tape, and the driver pushes a button to play the next instruction.) This interface imposes a new requirement on the form of the directions. Since they are to be heard and acted on in real time, it is important to repeat essential information so that it can be remembered. In our interface, we assume people are writing down the directions before they begin to drive, so repetition is not crucial. (The user can ask the Narrator to replay an instruction if it is not understood.)

They classify turns into ordinary turns, "T" turns, complex intersections, turns in short succession, and continues. Their "T" turn is our "forced turn" cue. The difference between an ordinary turn and a "T" turn is that the latter needs no failure cue. So our treatments are similar. We do not distinguish complex intersections, though we should. The Route Finder should avoid them, and the Describer should warn about them.

Their instructions are sometimes more structured than ours. They cluster turns which occur close to each other into a single instruction block, and their "continue" is just our "name change", but is also incorporated into the following turn. We recognize the importance of providing higher levels of structure, and wish to remind the reader that Streeter and company were working by hand, not with a program, and were in a better position to form hierarchies than we.

We claim that our directions are more natural than those of Elliot and Lesk, but have no proof for this. We leave it to the reader to judge.

Are our directions clear? We know that people have been able to follow them, but we have not made any systematic test. Christoper Riesbeck wrote a program (MCMAP) which judged the clarity of directions. Our directions would not be acceptable to it, to judge from its published description. Partly this is because we talk about features the program does not know, for example rotaries, but also because his program explicitly rejects use of miles for distance as inherently unclear. We use mileage only as an approximation, as a cue for when to look for a landmark, but the weak syntactic powers of MCMAP would not notice this. Also, we use "drive all the way to end", which Riesbeck terms a "procedural operator", and did not implement. Since people accept our directions, this suggests that Riesbeck's rules are too strict, or perhaps not powerful enough.

5 Discussion

Products like Direction Assistance are beginning to appear in the marketplace. It is reported that ETAK, of Sunnyvale California, has a product (the Navigator) which, installed in a car, estimates the car's position by counting wheel rotation and turning angle and comparing results with a stored map. A display in the dashboard displays the local area and the position of the car. The Navigator does not supply driving directions, but surely could be made to do so.

A more similar product is DriverGuide, made by Karlin and Collins, also of Sunnyvale, which is reported to produce printed directions for travel in the Bay Area[8].

5.1 Better databases are required

Any serious use of Direction Assistance requires further improvements to the street map. The area covered is too small, and even the small region covered is not fully mapped. More significantly, there are additional facts that the current street database format can not represent.

Among these are time-dependent legal restrictions (e.g. "no left turn during rush hour"), restriction of height, weight, and prohibition of commercial vehicles, multiple names of streets, presence of stop lights, and landmarks. In addition, the representation of addresses is not sufficient. We have seen addresses with fractions and with letters, and there are also streets where both even and odd numbers are on the same side of the street.

A practical system must account for multiple names. When Route 93 passes through Boston, it is also Route 3, the Fitzgerald Expressway, and the Southeast Expressway. When Massachusetts Avenue turns north at Harvard Square, only the southbound lane is "really" Massachusetts Avenue. The other direction is officially Peabody Street. We do not know which name to use when naming these streets, but we should at least be able to accept all synonyms on input.

Boston, like any city, changes its configuration of streets daily. Some changes, e.g. for construction, are temporary, although they may persist for years. Others are permanent. Streets are built and removed, and sometimes they change names or directions. A practical system requires accurate and timely corrections to the database.

We could give better directions with a better database, giving, for example the location of traffic lights or landmarks such as gas stations. Elliot and Lesk were able to capture business locations from an online Yellow Pages. To be more ambitious, we might hope for a representation rich enough to capture the qualities of image and orientation described by Kevin Lynch[7]. We have no proposal for how to do this at present.

5.2 Applications

We initially designed Direction Assistance with tourists in mind. Boston's confusing streets often lead the visitor astray. A tourist's direction guide could be provided by the city, or as a profitable venture. But a tourist may not know the street address or phone number for the destination. In fact, there may not be one, for the destination might be a general area, such as a neighborhood or park. Tourists would probably prefer to identify locations by name. It might be difficult to add this feature without making the interface more complicated.

Direction Assistance could direct people to services. Given the caller's location and the type of service desired, Direction Assistance could select the closest, and provide a route. This service might be dedicated to a single vendor (e.g. for banking machines) or as an advertising service for many customers.

Routing delivery vehicles pose special problems. Some of the most useful routes in Boston are closed to commercial vehicles, either for legal reasons or because they have such low underpasses that even scofflaws can not get through. We could extend the street database to record such facts.

We also feel compelled to mention the implications of Direction Assistance for privacy. Should a public Direction Assistance include home telephone numbers? People may want to keep the ability to give out their home phone numbers without also revealing their addresses to callers. One can hang up on an annoying caller. A visitor may be harder to dispose of.

Acknowledgments

A prototype version was written by Dinarte R. Morais during the winter of 1985. We are indebted to him for decoding the DIME files, the initial window system interface, and the proof of concept. We made extensive use of a database package and string matcher written by Craig Stanfill. Charles Lieserson made major improvements to the search algorithm of the Route Finder. Fletch McCellan of the PhoneBook Corporation loaned us the raw phone book database. This work would not have happened without the guidance and persistence of Brewster Kahle. This paper was much clarified by the comments of Janet Cahn, Mike Hawley, Margaret Minksy, and Chris Schmandt. We thank them all.

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This paper bears the names of two authors, for the program was joint work. But though it is written in the plural, it is the work of only one of us. I dedicate it to Tom, who did not survive to see his work described. Though too small a memorial, it is the best I can manage at this time.

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EXHIBIT 26

IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF MASSACHUSETTS

MASSACHUSETTS INSTITUTE OF TECHNOLOGY, Plaintiff, v. HARMAN INTERNATIONAL INDUSTRIES, INCORPORATED, Defendant.	Civil Action No.: 05-10990 DPW Magistrate Judge Judith G. Dein

DECLARATION OF LYNN A. STREETER, PH.D.

I, Lynn A. Streeter, state the following:

1. I am President of Pearson Knowledge Technologies. I have been retained as a testifying expert in this case, and have previously submitted an expert report and been deposed in this litigation.

2. I was aware of the "Back Seat Driver" doctoral research being undertaken by James R. Davis in the 1988-1990 timeframe from my personal contact with one of my colleagues at Bellcore, Mike Lesk, and with Jim Davis.

3. Mike Lesk was on Davis' thesis committee. Sometime after Davis defended and finalized his thesis, Mike Lesk or Jim Davis provided me with a copy of Davis' thesis. As I testified during my deposition, I do not recall the precise date on which I actually received a draft of Jim Davis' thesis. I understood at the time that Davis' thesis was not a public document and that I was provided a copy on the understanding that I would not distribute or disseminate the document until after it became publicly available.

4. Harman's Statement of Undisputed Facts, at paragraph 8 says "Davis sent another copy of his thesis (unsigned but bearing an August 4, 1989 date for Davis' signature) to a Bellcore employee, Lynn Streeter, without any confidentiality designation and without any restriction on her use of it...(Dr. Streeter then forwarded Davis' Thesis to third parties)." Harman does not say when I received the thesis draft, nor when I allegedly forwarded Jim's thesis to any third parties. I do not believe the copy of the thesis I received was a priority or rush copy such that I would have gotten a copy before Jim Davis defended his thesis or before the thesis was public.

5. I understand that Harman points to a note produced from my files to suggest that I sent Davis' thesis to a third party, Karen Lochbaum, without any kind of confidentiality. This document bears a Bates number of STREETER00052. This document does not have a date on it.

I believe that this document was created after Davis' thesis became publicly available. I do not believe that if I sent a copy to Karen Lochbaum that I did so immediately after receiving my copy of it or on an otherwise urgent basis. More than likely, I found the thesis while cleaning my office sometime later, and thought Karen might be interested in seeing the thesis since she was a graduate student at Harvard studying dialog issues.

6. Harman further claims that I received the thesis "the day it was published" (Statement of Undisputed Facts, paragraph 9). However, as I testified during my deposition, I do not recall the exact date on which I received the thesis and do not believe that I received a copy of the thesis before Jim had defended it. I also did not testify that I received Jim's thesis "the day it was published," what I said was I thought I got a copy "about the same time" as Mike Lesk went to Cambridge for the thesis defense. I also do not believe that I received a copy of Davis' thesis before Mike Lesk did, who was on Jim's thesis committee.

7. I understood at the time that in the academic environment, research results and theses drafts are sometimes circulated among close groups of colleagues for comment or feedback, but that these results and drafts were not to be published by others without the agreement of the researcher or author.

8. I believe that Davis and Schmandt considered me a research colleague and trusted confidante based on my earlier research and collaboration with them. I understood that communications between myself and Davis or Schmandt were considered private communications that were not public or for public distribution.

I swear under penalty of perjury that all of foregoing information is true today, and is consistent with sworn testimony I would have given during my deposition on September 13, 2006 if asked by counsel for Harman.

Dated: May 22, 2007

Lynn A. Streeter

Lynn A. Streeter, Ph.D.